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MANUAL OF SEPTIC-TANK PRACTICE, DEVELOPED IN COOPERATION WITH THE JOINT COMMITTEE ON RURAL SANITATION

Public Health Service
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*Addendum to Part I *Manual of Septic Tank Practice*
PHS Publication No. 526

The provisions regarding the need for distribution boxes in soil absorption systems for private residences are based on the premise that uniform distribution of effluent over the total designed absorption area is necessary. Distribution boxes have been employed in an effort to obtain uniform or parallel distribution.

Recent studies sponsored by the Federal Housing Administration have demonstrated that various arrangements in the tile field, including the distribution box, do not achieve uniform distribution. Furthermore, it has never been established that equal distribution has any advantages as opposed to some arrangement of serial distribution. Serial distribution is achieved by arranging individual trenches of the absorption system so that each trench is forced to pond to the full depth of the gravel fill before liquid flows into the succeeding trench. In this manner, the total absorption area of the entire system is utilized before ultimate failure can occur.

Serial distribution has the following advantages:

1. Serial distribution minimizes the importance of variable absorption rates by forcing each trench to absorb effluent until its ultimate capacity is utilized. The variability of soils even in the small area of an individual absorption field raises doubt of the desirability of uniform distribution. Any one or a combination of factors may lead to nonuniform absorptive capacity of the several trenches in a system. Varying physical and chemical characteristics of the soil, construction damage such as soil interface smearing or excessive compaction, poor surface drainage, and variation in depth of trenches are some of the factors involved.

2. Serial distribution causes each trench in the absorption system to be used to full capacity before failure occurs. Serial distribution has a distinct advantage on sloping terrain. With imperfect division of flow in a parallel system, one trench could become overloaded, resulting in a surcharged condition. If the slope of the ground and elevation of the distribution box were such that a surcharged trench continued to receive more effluent than it could absorb, local failure would occur before the full capacity of the system was utilized.

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*August 1, 1959.

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1.A

3. The cost of the distribution box is eliminated in serial distribution. Also, long runs of closed pipe connecting the box to each trench are unnecessary.

RECOMMENDED MODIFICATIONS OF ABSORPTION FIELD DESIGN

A. Fields in Flat Areas

Where the slope of the ground surface does not exceed six inches in any direction within the area utilized for the absorption field, the septic tank effluent may be applied to the absorption field through a system of interconnected tile lines and trenches in a continuous system. The following specific criteria should be followed:

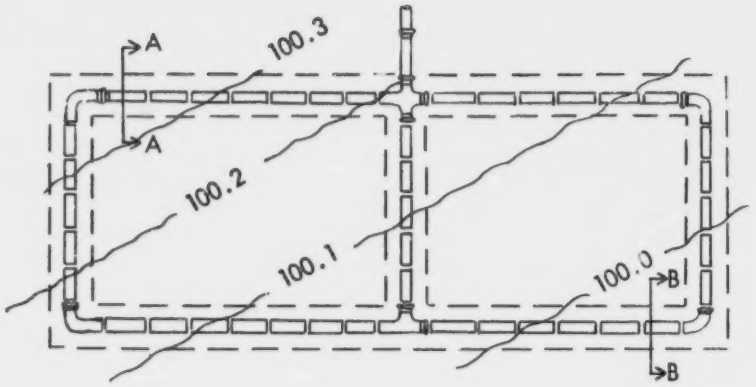
1. A minimum of 12 inches of earth cover is provided over the gravel fill in all trenches of the system.
2. The bottom of the trenches and the distribution lines are constructed on a relatively level grade.
3. Other construction features of the disposal field are the same as recommended in the *Manual of Septic-Tank Practice*. One type of a satisfactory absorption system layout for "level" ground is shown in figure A, attached.

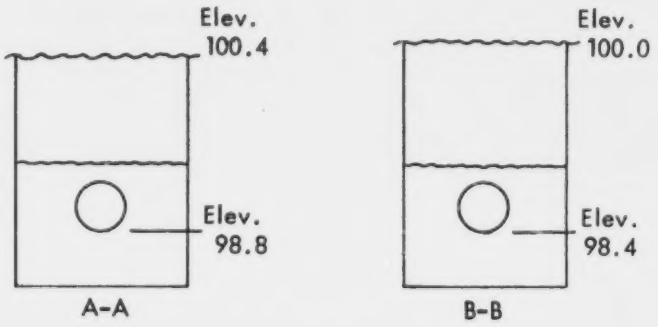
B. Fields in Sloping Ground

Serial distribution may be used in all situations where a soil absorption system is permitted and *should be used where the fall of the ground surface exceeds approximately 6 inches in any direction within the area utilized for the absorption field.* The maximum ground slope suitable for serial distribution systems should be governed by local factors affecting the erosion of the ground used for the absorption field. Excessive slopes which are not protected from surface water runoff or do not have adequate vegetation cover to prevent erosion should be avoided. Generally, ground having a slope greater than one vertical to two horizontal should be investigated carefully to determine if satisfactory from the erosion standpoint. Also, the horizontal distance from side of the trench to the ground surface should be adequate to prevent lateral flow of effluent and breakout on surface.

In serial distribution, each adjacent trench (or pair of trenches) is connected to the next by a closed pipe line laid on an undisturbed section of ground, as shown in Figure B attached. The arrangement is such that all effluent is discharged to the first trench until it is filled. Excess liquid is then carried by means of a closed line to the next succeeding or lower trench. In that manner, each portion of the subsurface system is used in succession. When serial distribution is used, the following design and construction procedures should be followed:

1. The amount of absorption area required shall be the same as shown in table 1, page 6, of the *Manual of Septic-Tank Practice.*
2. The bottom of each trench and its distribution line should have a relatively level grade.





1. Max. difference in elevation of distribution tile cannot exceed 6 inches.
2. Min. earth cover over trenches 12 inches.

A DISTRIBUTION ARRANGEMENT
FOR LEVEL GROUND
Figure A

3. There should be a minimum of 12 inches of ground cover over the gravel fill in the trenches.

4. The absorption trenches should follow approximately the ground surface contours so that variations in trench depth will be minimized.

5. There should be a minimum of 6 feet of undisturbed earth between adjacent trenches, and between the septic tank and the nearest trench.

6. Adjacent trenches may be connected with the relief line or a drop box arrangement (fig. B) in such a manner that each trench is completely filled with septic tank effluent to the full depth of the gravel before effluent flows to succeeding trenches. (The sketches shown do not preclude the use of other arrangements to provide serial distribution.)

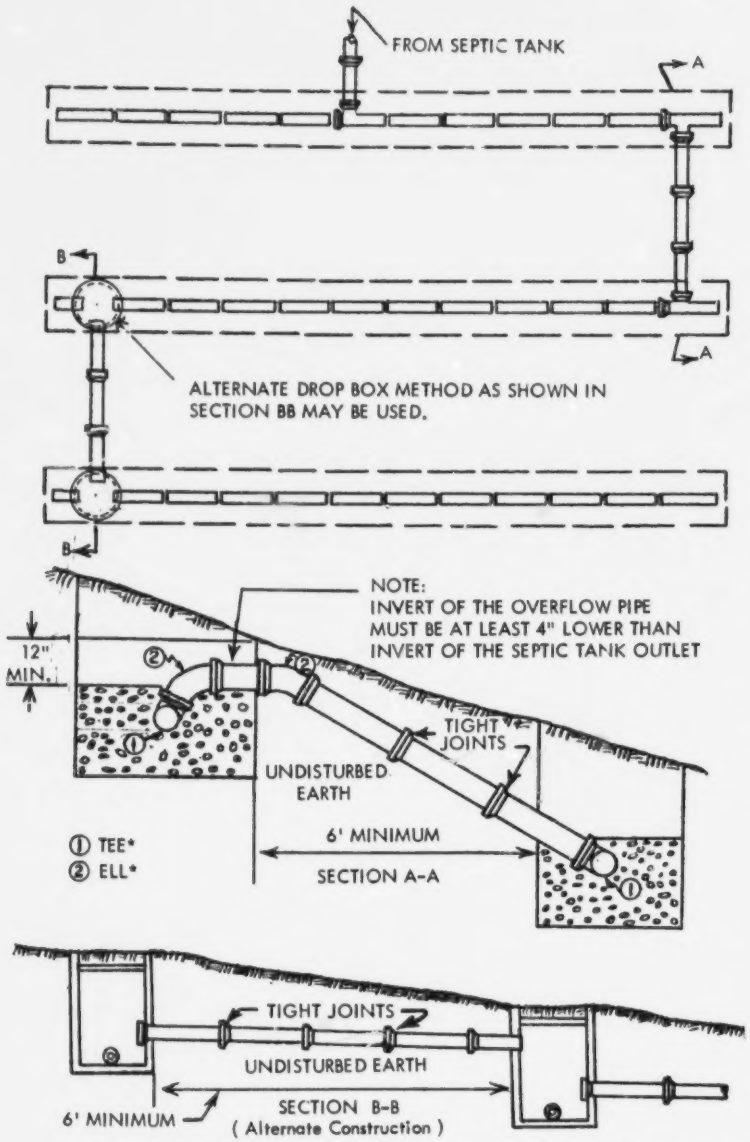
a. Trench connecting lines should be 4-inch tight-joint sewers with direct connections to the distribution lines in adjacent trenches or to a drop box arrangement.

b. Care must be exercised in constructing relief lines to insure an undisturbed block of earth between trenches. The trench for the relief pipe, where it connects with the preceding absorption trench, shall be dug no deeper than the top of the gravel. The relief line should rest on undisturbed earth and backfill should be carefully tamped.

c. The relief lines connecting individual trenches should be as far from each other as practicable in order to prevent short-circuiting.

7. Invert of the overflow pipe in the first relief line must be at least 4 inches lower than the invert of the septic tank outlet (fig. B).

8. All other construction features of the disposal field are the same as recommended in the *Manual of Septic-Tank Practice.*



* DIFFERING GROUND SLOPES OVER SUBSURFACE DISPOSAL FIELD MAY REQUIRE USE OF VARIOUS COMBINATIONS OF FITTINGS.

A RELIEF LINE ARRANGEMENT FOR SERIAL DISTRIBUTION

Figure B

PB 218 226

Manual of SEPTIC-TANK PRACTICE

Developed in Cooperation with the Joint Committee on Rural Sanitation

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service | Bureau of State Services
Division of Sanitary Engineering Services

Public Health Service Publication No. 526

Foreword

This Manual of Septic Tank Practice has been prepared for use as a guide by health agencies, building officials, installers, and others, to meet the need for an authoritative treatise on the subject. The material is based in large measure on the results of extensive research studies carried on at the Robert A. Taft Sanitary Engineering Center. Further research is being conducted at the Center which may provide additional data on alternate methods of treatment and disposal.

In the preparation of this manual, the Public Health Service was fortunate in having the advisory assistance of the Joint Committee on Rural Sanitation. This committee is composed of specialists from governmental and other agencies in the field of rural sanitation. Their comments and suggestions based on the long experience of the members were invaluable in the preparation of the manual. The following individuals and organizations constitute the current Committee membership:

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The basic responsibility for preparation of the original draft was assumed by Senior Sanitary Engineer James B. Coulter and Professor John E. Kiker. Credit is also due Harvey F. Ludwig, Thomas W. Bendixen, C. C. Johnson, and Samuel Weibel for their very substantial contributions to the Manual.

M. D. HOLLIS,
Chief Engineer.

Preface

In recent years, there has been steady movement of population from the cities to the surrounding fringe areas. For economic and other reasons, the extension of public sewers has not kept pace with the relocation of population. As a result, the individual sewage-disposal system has taken a prominent place in the overall practice of sewage treatment. Accurate figures are not available, but it is estimated that at present 24 millions persons are served by 6 million individual sewage-disposal systems in the United States. Of even more importance, roughly one-third of the new homes are being constructed with these systems.

In 1946, the Public Health Service, in cooperation with Federal agencies concerned with housing, undertook a 5-year study on septic-tank soil-absorption systems, seeking to develop a factual basis on which they could be designed, installed, and maintained. These studies are described in detail in three technical reports, *Studies on Household Sewage Disposal Systems*, Parts I, II, and III. This manual incorporates those findings with the results of other studies and field experience so that officials, homeowners, and builders may have the best information available.

The decision on the suitability of septic-tank installations must be based on many factors outside of those covered in the manual. It is emphasized, however, that connection to an adequate public sewerage system is the most satisfactory method of disposing of sewage. Every effort should be made, therefore, to secure public-sewer extensions. Where connection to a public sewer is not feasible, and when a considerable number of residences are to be served, consideration should be given next to the construction of a community sewerage system and treatment plant. Specific information on this matter should be obtained from the local authority having jurisdiction.

Individuals proposing to construct individual sewage-disposal systems should consult the officials having jurisdiction over such installations in their area. A number of States and localities have developed requirements which have been incorporated in their official regulations, in many cases soundly based on conditions peculiar to those areas and adequately representing good practice there. The recommendations contained in this manual should be considered as supplemental to such local requirements. Builders, homeowners, and others interested in septic-tank systems should seek advance guidance from the local authorities prior to

land acquisition, in order to have the benefits of their experience as well as their approval of plans and construction.

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Robert A. Taft Sanitary Engineering Center
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Part 1

Septic-Tank Systems for Private Residences

INTRODUCTION

A major factor influencing the health of individuals where public sewers are not available is the proper disposal of human excreta. Many diseases, such as typhoid fever, dysentery, and various types of diarrhea are transmitted from one person to another through the fecal contamination of food and water, largely due to the improper disposal of human wastes. For this reason, every effort should be made to prevent such hazards and to dispose of all human waste so that no opportunity will exist for contamination of water or food.

Safe disposal of all human and domestic wastes is necessary to protect the health of the individual family and the community and to prevent the occurrence of nuisances. To accomplish satisfactory results, such wastes must be disposed of so that:

1. They will not contaminate any drinking water supply.
2. They will not give rise to a public-health hazard by being accessible to insects, rodents, or other possible carriers which may come into contact with food or drinking water.
3. They will not give rise to a public-health hazard by being accessible to children.
4. They will not violate laws or regulations governing water pollution or sewage disposal.
5. They will not pollute or contaminate the waters of any bathing beach, shellfish-breeding ground, or stream used for public or domestic water-supply purposes, or for recreational purposes.
6. They will not give rise to a nuisance due to odor or unsightly appearance.

These criteria can best be met by the discharge of domestic sewage to an adequate public or community sewerage system. Where the installation of an individual household sewage-disposal system is necessary, the basic principles outlined in this manual on design, construction, installation, and maintenance should be followed. When these criteria are met, and where soil and site conditions are favorable, the septic-tank

system can be expected to give satisfactory service. Experience has shown that adequate supervision and inspection of all features of the system are required to insure compliance in this respect. Underground portions of the system should be inspected before being covered, so necessary corrections can be made.

SUITABILITY OF SOIL

The first step in the design of subsurface sewage-disposal systems is to determine whether the soil is suitable for the absorption of septic-tank effluent and, if so, how much area is required. The soil must have an acceptable percolation rate, without interference from ground water or impervious strata below the level of the absorption system. In general, two conditions must be met:

(1) The percolation time should be within the range of those specified in Table 1, p. 6.

(2) The maximum elevation of the ground-water table should be at least 4 feet below the surface. Rock formations or other impervious strata should be at a depth greater than 4 feet below the bottom of trench or seepage pit.

Unless these conditions are satisfied, the site is unsuitable for a subsurface sewage-disposal system, except for isolated systems.

PERCOLATION TESTS

Subsurface explorations are necessary to determine subsurface formations in a given area. An auger with an extension handle, as shown in figure 1 (p. 3), is often used for making the investigation. In some cases, an examination of road cuts, stream embankments, or building excavations will give useful information. Wells and well-drillers' logs can also be used to obtain information on ground water and subsurface conditions. In some areas, subsoil strata vary widely in short distances, and borings must be made at the site of the system. If the subsoil appears suitable, percolation tests should be made at points and elevations selected as typical of the area in which the disposal field will be located.

The percolation tests determine the acceptability of the site and the design of the subsurface disposal system. The length of time required for percolation tests will vary in different types of soil. The safest method is to make tests in holes which have been kept filled with water for at least 4 hours, preferably overnight. This is particularly desirable if the tests are to be made by an inexperienced person, and in some soils it is necessary even if the individual has had considerable experience (as in soils which swell upon wetting). Percolation rates should be figured on the basis of the test data obtained after the soil has had opportunity to become wetted or saturated and has had opportunity to swell for at

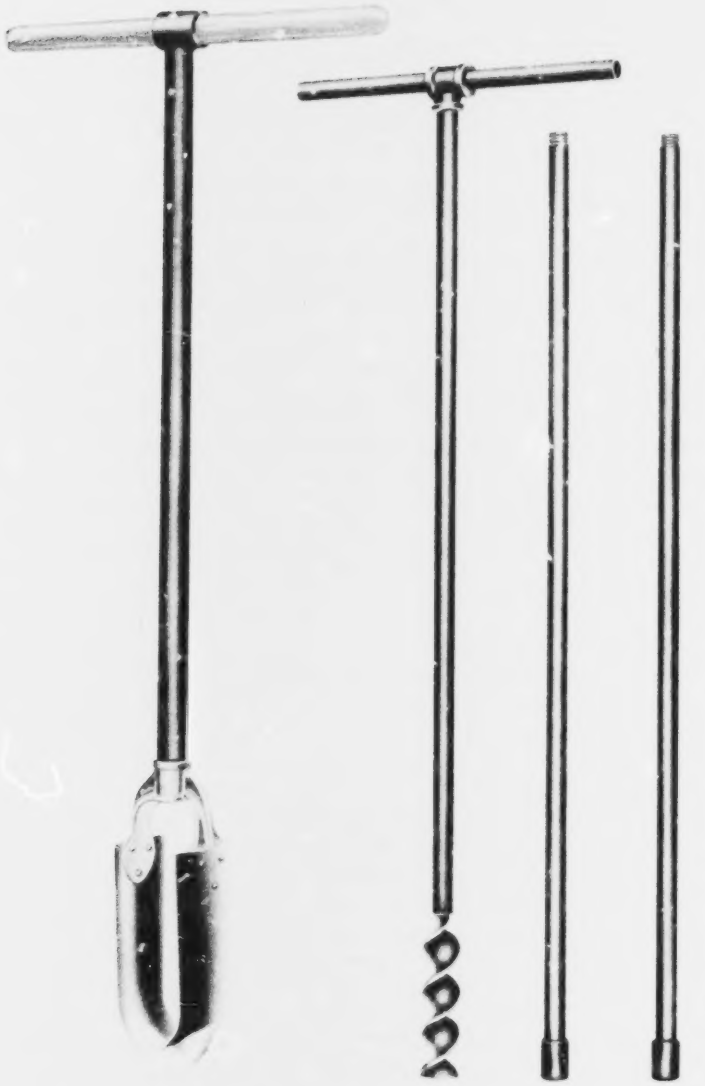


Figure 1.—Auger and extension handle for making test borings.

least 24 hours. Enough tests should be made in separate holes to assure that the results are valid.

The percolation test developed at the Robert A. Taft Sanitary Engineering Center incorporates these principles. Its use is particularly recommended when knowledge of soil types and soil structure is limited. When previous experience and information on soil characteristics are available, some persons prefer other percolation test procedures, such as those developed by Kiker and by Ludwig which are cited in Appendix A.

Procedure for Percolation Tests Developed at Robert A. Taft Sanitary Engineering Center

1. *Number and location of tests.*—Six or more tests shall be made in separate test holes spaced uniformly over the proposed absorption-field site.

2. *Type of test hole.*—Dig or bore a hole, with horizontal dimensions of from 4 to 12 inches and vertical sides to the depth of the proposed absorption trench. In order to save time, labor, and volume of water required per test, the holes can be bored with a 4-inch auger. (See Fig. 2, page 5.)

3. *Preparation of test hole.*—Carefully scratch the bottom and sides of the hole with a knife blade or sharp-pointed instrument, in order to remove any smeared soil surfaces and to provide a natural soil interface into which water may percolate. Remove all loose material from the hole. Add 2 inches of coarse sand or fine gravel to protect the bottom from scouring and sediment.

4. *Saturation and swelling of the soil.*– It is important to distinguish between saturation and swelling. Saturation means that the void spaces between soil particles are full of water. This can be accomplished in a short period of time. Swelling is caused by intrusion of water into the individual soil particle. This is a slow process, especially in clay-type soil, and is the reason for requiring a prolonged soaking period.

In the conduct of the test, carefully fill the hole with clear water to a minimum depth of 12 inches over the gravel. In most soils, it is necessary to refill the hole by supplying a surplus reservoir of water, possibly by means of an automatic syphon, to keep water in the hole for at least 4 hours and preferably overnight. Determine the percolation rate 24 hours after water is first added to the hole. This procedure is to insure that the soil is given ample opportunity to swell and to approach the condition it will be in during the wettest season of the year. Thus, the test will give comparable results in the same soil, whether made in a dry or in a wet season. In sandy soils containing little or no clay, the swelling procedure is not essential, and the test may be made as described under item 5C, after the water from one filling of the hole has completely seeped away.

5. *Percolation-rate measurement.*—With the exception of sandy soils, percolation-rate measurements shall be made on the day following the procedure described under item 4, above.

A. If water remains in the test hole after the overnight swelling period, adjust the depth to approximately 6 inches over the gravel. From a fixed reference point, measure the drop in water level over a 30-minute period. This drop is used to calculate the percolation rate.

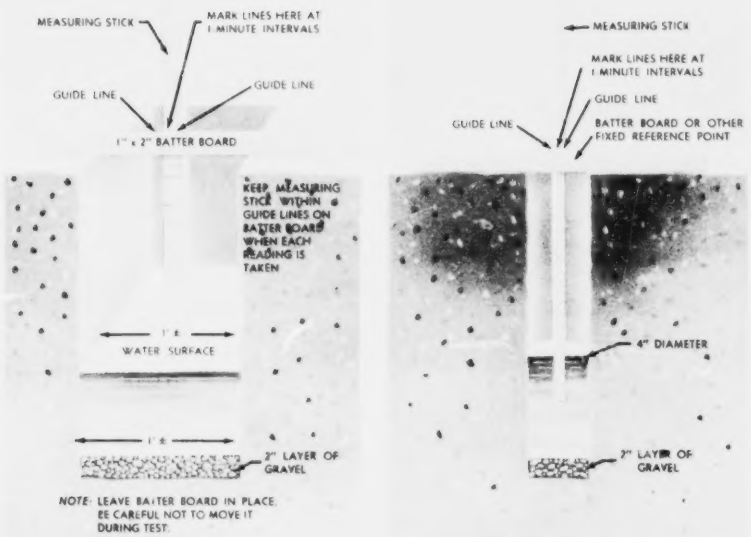

MEASURING STICK
MARK LINES HERE AT 1 MINUTE INTERVALS
GUIDE LINE
GUIDE LINE
1" x 2" BATTER BOARD
KEEP MEASURING STICK WITHIN 4 GUIDE LINES ON BATTER BOARD WHEN EACH READING IS TAKEN
1" ±
WATER SURFACE
1" ±
2" LAYER OF GRAVEL
NOTE: LEAVE BATTER BOARD IN PLACE. BE CAREFUL NOT TO MOVE IT DURING TEST.
MEASURING STICK
MARK LINES HERE AT 1 MINUTE INTERVALS
GUIDE LINE
GUIDE LINE
BATTER BOARD OR OTHER FIXED REFERENCE POINT
4" DIAMETER
2" LAYER OF GRAVEL

Figure 2.—Methods of making percolation tests.

B. If no water remains in the hole after the overnight swelling period, add clear water to bring the depth of water in the hole to approximately 6 inches over the gravel. From a fixed reference point, measure the drop in water level at approximately 30-minute intervals for 4 hours, refilling 6 inches over the gravel as necessary. The drop that occurs during the final 30-minute period is used to calculate the percolation rate. The drops during prior periods provide information for possible modification of the procedure to suit local circumstances.

C. In sandy soils (or other soils in which the first 6 inches of water seeps away in less than 30 minutes, after the overnight swelling period), the time interval between measurements shall be taken as 10 minutes and the test run for 1 hour. The drop that occurs during the final 10 minutes is used to calculate the percolation rate.

Table I.—*Absorption-area requirements for private residences*

[Provides for Garbage-Grinder and Automatic-Sequence Washing Machines]

Percolation rate (Time required for water to fall 1 inch, in minutes)	Required absorption area, in square feet per bedroom [1] standard trench [2] and seepage pits [3]	Percolation rate (Time required for water to fall 1 inch, in minutes)	Required absorption area, in square feet per bedroom [1] standard trench [3] and seepage pits [3]
1 or less	70	10	165
2	85	15	190
3	100	30 [4]	250
4	115	45 [4]	300
5	125	60 [4 5]	330

[1] In every case, sufficient area should be provided for at least 2 bedrooms.

[2] Absorption area for standard trenches is figured as trench-bottom area.

[3] Absorption area for seepage pits is figured as effective side-wall area beneath the inlet.

[4] Unsuitable for seepage pits if over 30.

[5] Unsuitable for leaching systems if over 60.

LEACHING SYSTEM

For areas where the percolation rates are good, the next step after making the percolation tests is to determine the required absorption area from Table I (page 6) or Figure 2 (page 5), and to select the leaching system that will be satisfactory for the area in question. As noted in Table I, soil in which the percolation rate is slower than 1 inch in 30 minutes is unsuitable for seepage pits, and that slower than 1 inch in 60 minutes is unsuitable for any type of soil-absorption disposal system. Therefore, such areas should not be used until or unless suitable alternate facilities are available. When a soil-absorption system is determined to be usable, two types of design may be considered—standard trenches and seepage pits. Each of these are discussed, and examples of calculations for their design are presented. (Variations in design of absorption systems utilizing increased width or depth have been used in some areas. There is a recognized need for research studies to establish design criteria for such systems. A suggested approach is described in Appendix B (page 71), which may be followed by those who desire to

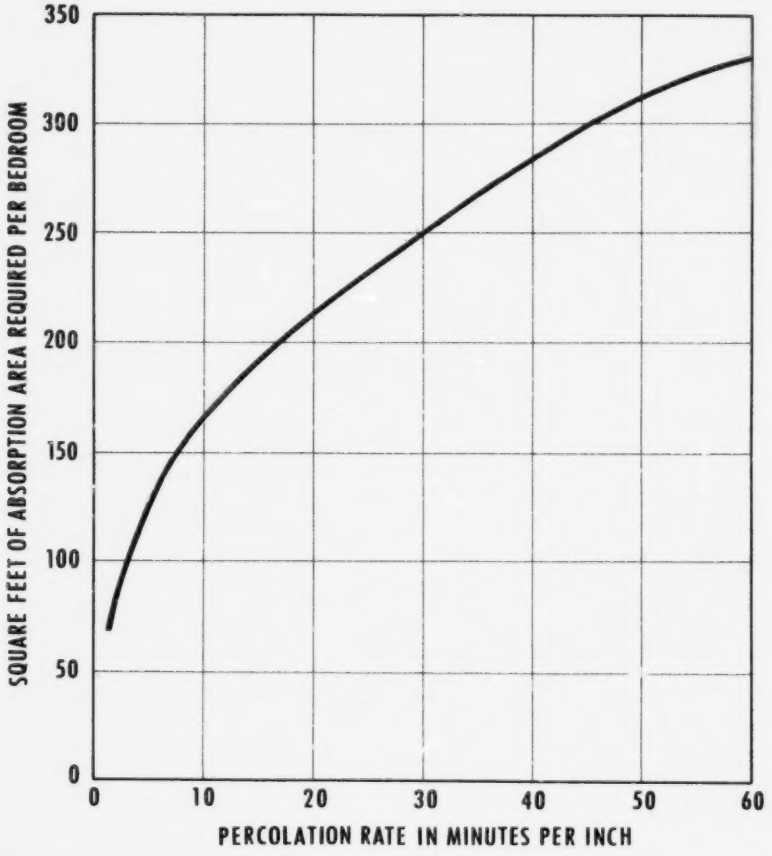


Figure 3.—Absorption area requirements for private residences.

develop experience in their use. This departure from standard practice is not recognized for general application.)

The selection of the leaching system will be dependent to some extent on the location of the system in the area under consideration. A safe distance should be maintained between the site and any source of water supply. Since the distance that pollution will travel underground depends upon numerous factors, including the characteristics of the subsoil formations and the quantity of sewage discharged, it is not practical to specify minimum distances that would be reasonable in all localities. Ordinarily, of course, the greater the distance, the greater will be the safety provided. In general, all subsurface absorption systems should be kept 100 feet from any water-supply well, 50 feet from any stream or watercourse, and 10 feet from dwellings or property lines. Seepage pits

should not be used in areas where domestic water supplies are obtained from shallow wells, or where there are limestone formations and sinkholes with connection to underground channels through which pollution may travel to water sources. Seepage pits should not be located within 20 feet of any dwelling or property line.

Details pertaining to local water wells, such as depth, type of construction, vertical zone of influence, etc., together with data on the geological formations and porosity of subsoil strata, should be considered in determining the safe allowable distance between wells and subsurface disposal systems.

Standard Trenches

An absorption field or subsurface tile system consists of a field of 12-inch lengths of 4-inch agricultural drain tile, 2- to 3-foot lengths of vitrified-clay sewer pipe, or perforated, nonmetallic pipe, laid in such a manner that flow from the septic tank will be distributed with reasonable uniformity into natural soil. The individual laterals preferably should not be over 60 feet long, with a maximum length of 100 feet, and the trench bottom and tile distribution lines should be laid at a grade of 2 to 4 inches per 100 feet and never to exceed 6 inches per 100 feet. Use of more and shorter laterals is preferred because if something should happen to disturb one line, most of the field will still be serviceable.

Many different designs may be used in laying out subsurface disposal fields. The choice may depend on the size and shape of the available disposal area, the capacity required, and the topography of the disposal area. A typical layout is illustrated in Figures 4 and 5 (pages 9 and 10). Enlarged details or sections of a trench are shown in Figure 6 (page 11).

Table 2.—*Distances between trenches*

Trench width, inches	Minimum distance between centerline of trenches, feet	Trench width, inches	Minimum distance between centerline of trenches, feet
12 to 18	6	24 to 30	7.0
18 to 24	6.5	30 to 36	7.5

The depth of the absorption-field trenches should be at least 18 inches. Additional depth may be needed for contour adjustment, extra aggregate under the tile, or other design purposes. In considering the depth of the absorption-field trenches, the possibility of tile lines freezing during prolonged cold period is raised. Freezing rarely occurs in a carefully constructed system kept in continuous operation. It is important dur-

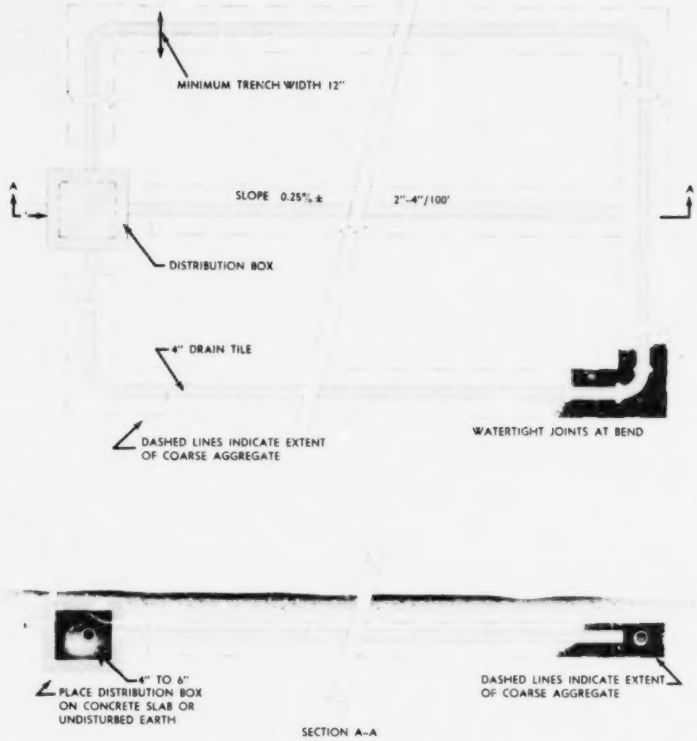

MINIMUM TRENCH WIDTH 12"
SLOPE 0.25%±
2"-4"/100'
DISTRIBUTION BOX
4" DRAIN TILE
DASHED LINES INDICATE EXTENT OF COARSE AGGREGATE
WATERTIGHT JOINTS AT BEND
4" TO 6"
PLACE DISTRIBUTION BOX ON CONCRETE SLAB OR UNDISTURBED EARTH
DASHED LINES INDICATE EXTENT OF COARSE AGGREGATE
SECTION A-A

Figure 4.—Absorption-field system for level ground.

ing construction to assure that the tile lines are surrounded by gravel. Pipes under driveways or other surfaces which are usually cleared of snow should be insulated.

Current design practice for soil absorption fields provides for trench width varying from 18 to 24 inches, with the tile laid on 6 inches of gravel. Within this range and for trenches up to 36 inches, the absorption area per linear foot of trench is proportioned to the width of the trench. The required absorption area is predicated on the results of the soil-percolation test, and may be obtained from column 2 of Table I (page 6) or Figure 3 (page 7). Note especially that the area requirements are per bedroom. Thus for a 3-bedroom house on a lot where the minimum percolation rate was 1 inch in 15 minutes, the necessary leaching trench area will be 3 feet x 190 feet, or 570 square feet. For trenches 2 feet wide with 6 inches of gravel below the drain tile, the required total length of trench would be 570÷2, or 285 feet. If this were divided into 5 portions (i. e., 5 laterals), the length of each line would be 285÷5, or 57 feet. The minimum spacing between tile

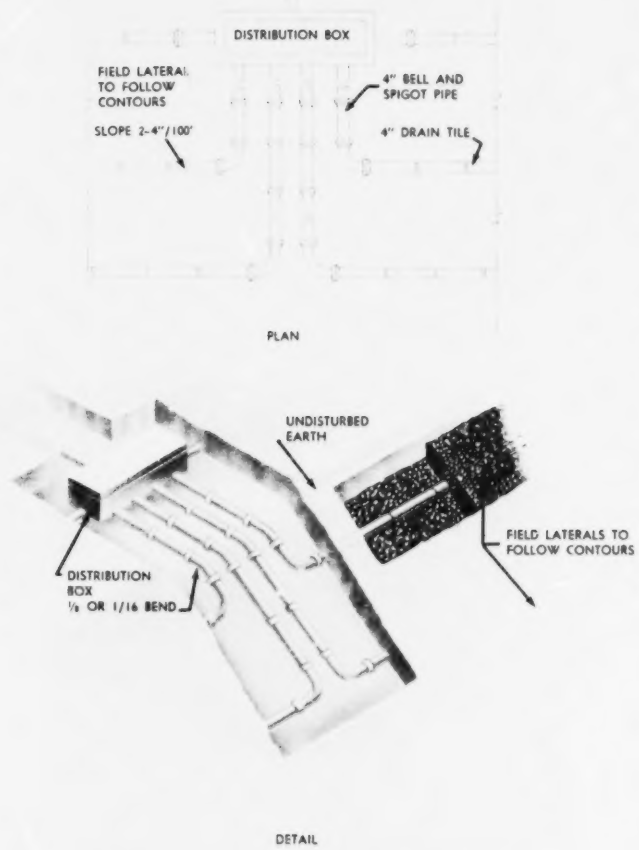
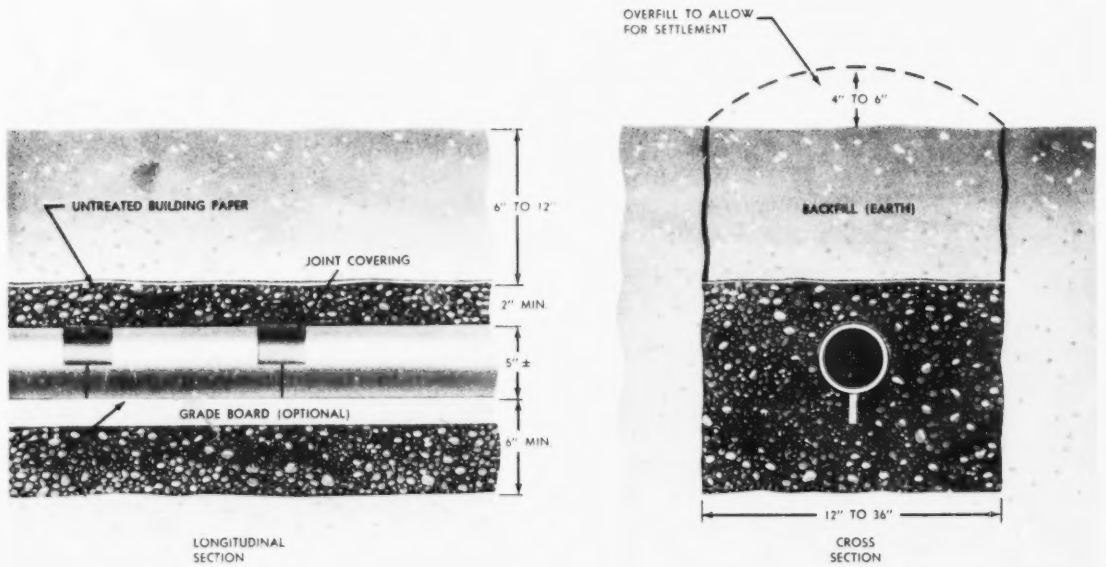


Figure 5.—Absorption-field system for sloping ground.

lines may vary between 6 to 7.5 feet, depending on the selected width of trench (Table 2, page 8). In the example cited, a minimum lateral spacing of 6.5 feet should be used. The minimum total area for the absorption field required would equal (5 x 6.5 x 57) 1,352 square feet.

Construction Considerations.—Careful construction is important in obtaining a satisfactory disposal field. Attention should be given to the protection of the natural absorption properties of the soil. Care must be taken to prevent sealing of the surface on the bottom and sides of the trench. Trenches should not be excavated when the soil is wet enough to smear or compact easily. Soil moisture is right for safe working only when a handful will mold with considerable pressure. Open trenches



NOTE: UNEVENNESS OF ENDS OF DRAIN TILE WILL USUALLY PROVIDE THE NECESSARY OPENINGS BETWEEN JOINTS. SPECIAL COLLARS MAY BE USED IF DESIRED.

Figure 6.—Absorption trench and lateral.

should be protected from surface runoff to prevent the entrance of silt and debris. If it is necessary to walk in the trench, a temporary board laid on the bottom will reduce the damage. Some smearing and damage is bound to occur. All smeared or compacted surfaces should be raked to a depth of 1 inch, and loose material removed, before the gravel is placed in the trench.

The tile, laid in a trench of sufficient width and depth, should be surrounded by clean, graded gravel, broken brick, washed rock, or similar aggregate. The material may range in size from ½-inch to 2½ inches. Cinders, broken shell, and similar material are not recommended, because they are usually too fine and may lead to premature clogging (or perforations). The material should extend from at least 2 inches above the top of the tile to at least 6 inches below the bottom of the tile. The upper half of the joint openings should be covered, as shown in Figure 6 (page 11). The top of the stone should be covered with untreated building paper or a 2-inch layer of hay, straw, pine needles, of similar material before placing the earth backfill. This will help prevent the stone from becoming clogged with the earth backfill. An impervious covering should not be used, as this interferes with evapotranspiration at the surface (see appendix, page 68). Although generally not figured in the calculations, evapotranspiration is often an important factor in the operation of horizontal leaching systems.

Drain-tile connectors, collars, clips, or other spacers with covers for the upper half of the joints are of value in obtaining uniform spacing, proper alignment, and protection of tile joints, but use of such aids is optional. They have been made of galvanized iron, copper, and plastic.

It has been found that root problems may be prevented best by using a liberal amount of gravel or stone around the tile. Clogging due to roots has occurred mostly in lines with insufficient gravel under the tile. Furthermore, roots seek the location where moisture conditions are most favorable for growth and, in the small percentage of cases where they become troublesome in well-designed installations, there is usually some explanation involving the moisture conditions. At a residence which is used only during the summer, for example, roots are most likely to penetrate when the house is uninhabited, or when moisture immediately below or around the gravel becomes less plentiful than during the period when the system is in use. In general, trenches constructed within 10 feet of large trees or dense shrubbery should have at least 12 inches of gravel or crushed stone beneath the tile.

The top of a new absorption trench should be hand-tamped and should be overfilled with about 4 to 6 inches of earth. Unless this is done, the top of the trench may settle to a point lower than the surface of the adjacent ground. This will cause the collection of storm water in the trench, which can lead to premature saturation of the absorption field and possibly to complete washout of the trench. Machine tamping or hydraulic backfilling of the trench should be prohibited.

Where sloping ground is used for the disposal area, it is usually necessary to construct a small temporary dike or surface-water diversion ditch above the field, to prevent the disposal area from being washed out by rain. The dike should be maintained or the ditch kept free of obstructions until the field becomes well covered with vegetation.

A heavy vehicle would readily crush the tile in a shallow absorption field. For this reason, heavy machinery should be excluded from the disposal area unless special provision is made to support the weight. All machine grading should be completed before the field is laid.

Distribution Boxes

A distribution box is considered essential for every absorption-field system. The purpose of the box is to insure equal distribution of effluent to the several lateral lines. In the conventional field, especially on sloping ground, the box is necessary to prevent overloading and failure of one line while the others are left empty. Pipe fittings, tees, and wyes have been proposed for this purpose, but to obtain even distribution with them is a rare event, if not a virtual impossibility. At least two lateral lines should lead from the box, and enough additional laterals should be connected to the box to provide the required effective percolation area. The design of the system can be varied to meet most topographical conditions encountered, while giving proper grade and alignment for all laterals (figure 5, page 10).

A typical distribution box located between a septic tank and absorption system is shown in Figure 7 (page 14). Details of a small household distribution box are shown in Figure 8 (page 15).

Inspection

After a subsurface sewage disposal system has been installed and before it is used, the entire system should be tested and inspected. The septic tank should be filled with water and allowed to stand overnight to check for leaks. If leaks occur, they should be repaired. The distribution box and absorption field should be checked before the laterals are covered, to be sure that disposal systems are installed properly. Inspection before backfilling should be required by local regulations, even where approval of plans for the subsurface sewage-disposal system has been required before issuance of a building permit.

Seepage Pits

A seepage pit is a covered pit with open-jointed lining through which the septic-tank effluent may seep or leach into the surrounding porous soil. It is usually considered a less-desirable method of disposal than the

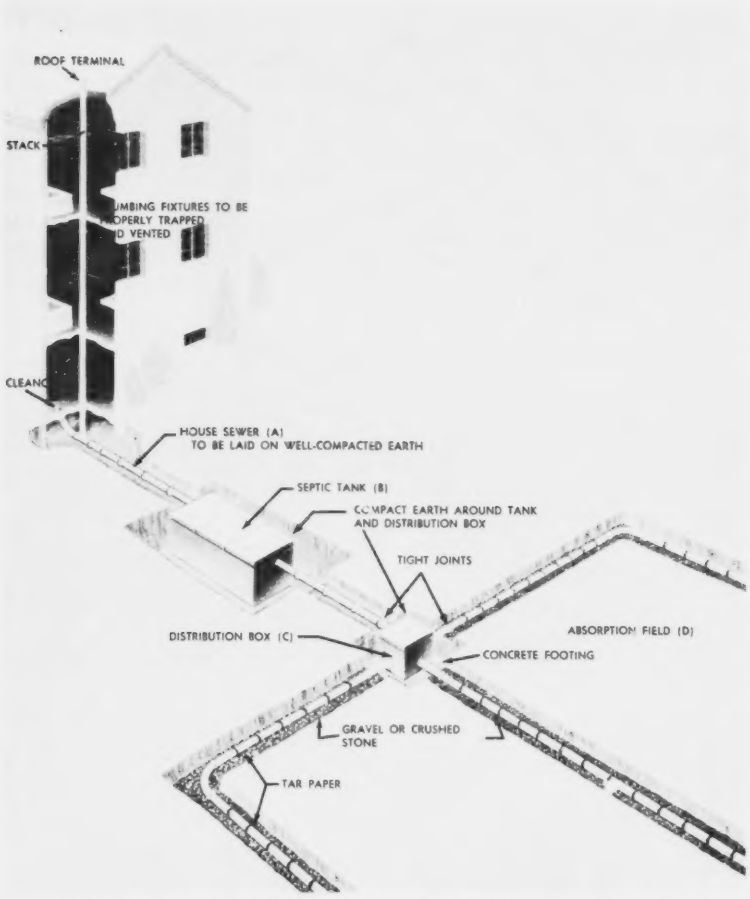


Figure 7.—Septic-tank sewage-disposal system.

absorption field. Seepage pits should never be used where there is a likelihood of contaminating underground waters, not where adequate subsurface disposal fields can be provided. When seepage pits are to be used in place of a subsurface tile field, the pit excavation should terminate 4 feet above the ground-water table.

In some States seepage pits are permitted as an alternative when absorption fields are impracticable, and where the top 3 or 4 feet of soil is underlaid with porous sand or fine gravel and the subsurface conditions are otherwise suitable for pit installations. Where circumstances permit, seepage pits may be either supplemental or alternative to the more shallow absorption fields. When seepage pits are used in combination with absorption fields, the leaching areas in each system should be pro-

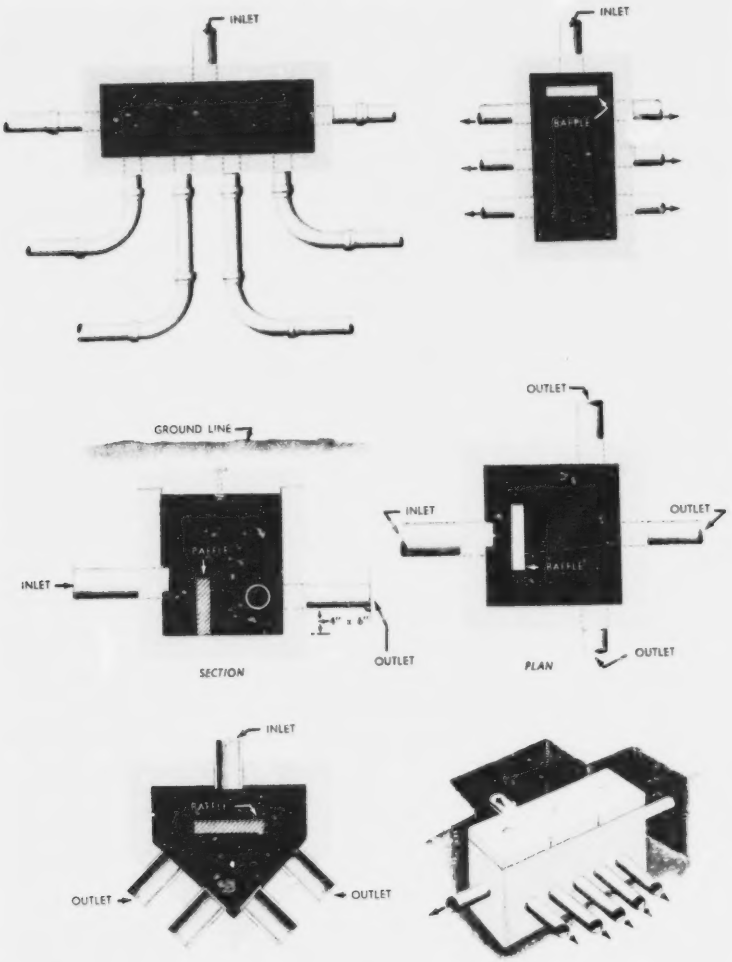


Figure 8.—Distribution boxes.

rated, or based upon the weighted average of the results of the percolation tests.

It is important that the capacity of a seepage pit be computed on the basis of percolation tests made in each vertical stratum penetrated. The weighted average of the results should be computed to obtain a design figure. Soil strata in which the percolation rates are in excess of 30 minutes per inch should not be included in computing the absorption area. As will be apparent from Figure 9 (page 16), adequate tests for deep pits are somewhat difficult to make, timeconsuming, and ex-

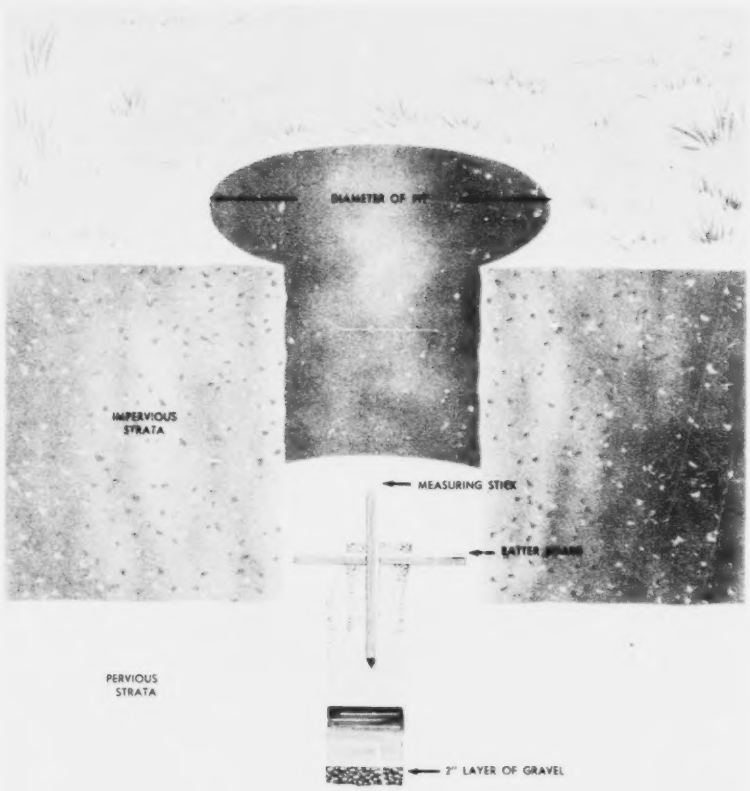


Figure 9.—Deep percolation test for seepage pit.

pensive. Although few data have been collected comparing percolation test results with deep-pit performance, nevertheless the results of such percolation tests, while of limited value, combined with competent engineering judgment based on experience, are the best means of arriving at design data for seepage pits.

Table I or Figure 3 (page 7) gives the absorption-area requirements per bedroom for the percolation rate obtained. The effective area of the seepage pit is the vertical-wall area (based on dug diameter) of the pervious strata below the inlet. No allowance should be made for impervious strata or bottom area. With this in mind, Table 3 may be used for determining the effective side-wall area of circular or cylindrical seepage pits.

Table 3.—*Vertical-wall areas of round seepage pits*

[In square feet]

Diameter of leaching pit (feet)	Effective strata depth below flow line (below inlet)									
	1 foot	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet	9 feet	10 feet
3	9.4	19	28	38	47	57	66	75	85	94
4	12.6	25	38	50	63	75	88	101	113	126
5	15.7	31	47	63	79	94	110	126	141	157
6	18.8	38	57	75	94	113	132	151	170	188
7	22.0	44	66	88	110	132	154	176	198	220
8	25.1	50	75	101	126	151	176	201	226	251
9	28.3	57	85	113	141	170	198	226	254	283
10	31.4	63	94	126	157	188	220	251	283	314
11	34.6	69	104	138	173	207	242	276	311	346
12	37.7	75	113	151	188	226	264	302	339	377

Example: A pit of 5-foot diameter and 6-foot depth below the inlet has an effective area of 94 square feet. A pit of 5-foot diameter and 16-foot depth has an area of 94+157, or 251 square feet.

Sample Calculations

Assume that a seepage-pit leaching system is to be designed for a 3-bedroom home on a lot where the minimum percolation rate of 1 inch in 15 minutes prevails. According to Table I, 3 x 190 (or 570) square feet of absorption area would be needed. Assume also that the water table does not rise above 27 feet below the ground surface, that seepage pits with effective depth of 20 feet can be provided, and that the house is in a locality where it is common practice to install seepage pits of 5-feet diameter (i. e., 4 feet to the outside walls, which are surrounded by about 6 inches of gravel). Design of the system is as follows:

Let x=depth of pit in feet; D=pit diameter in feet:

$$\pi Dx = 570 \text{ square feet.}$$

$$3.14(5)(x) = 570 \text{ square feet.}$$

Solving for x, depth of pit=36 feet (approx.)

In other words, one 5-foot-diameter pit 36 feet deep would be needed, but since the maximum effective depth is 20 feet in this particular location, it will be necessary to increase the diameter of the pit, or increase the number of pits, or increase both of these. This is illustrated in the example below:

(a) Design for 2 pits with a 10 foot diameter: x=depth of each pit.

$$2\,[3.14(10)(x)] = 570 \text{ square feet}$$

$$x = 9.1 \text{ feet deep}$$

Use 2 pits 10 feet in diameter and 9.1 feet deep.

(b) Design for 2 pits with a 5-foot diameter: x=depth of each pit.

$$2\ [3.14(5)(x)]=570 \text{ square feet}$$

$$x=18 \text{ feet (approximately)}$$

Use 2 pits 5 feet in diameter and 18 feet deep.

Experience has shown that seepage pits should be separated by a distance equal to 3 times the diameter of the largest pit. For pits over 20 feet in depth, the minimum space between pits should be 20 feet (See Fig. 10, page 18). The area of the lot on which the house is to be built should be large enough to maintain this distance between the pits while still allowing room for additional pits if the first ones should fail. If this can be done, such a leaching system may be approved; if not, other suitable sewerage facilities should be required.

Construction Considerations.—Seepage pits are usually circular in plan. As shown in Figure 11 (page 19), the vertical walls are usually lined with masonry placed without mortar below the inlet. The section of the seepage pit above the inlet pipe should be laid with mortared

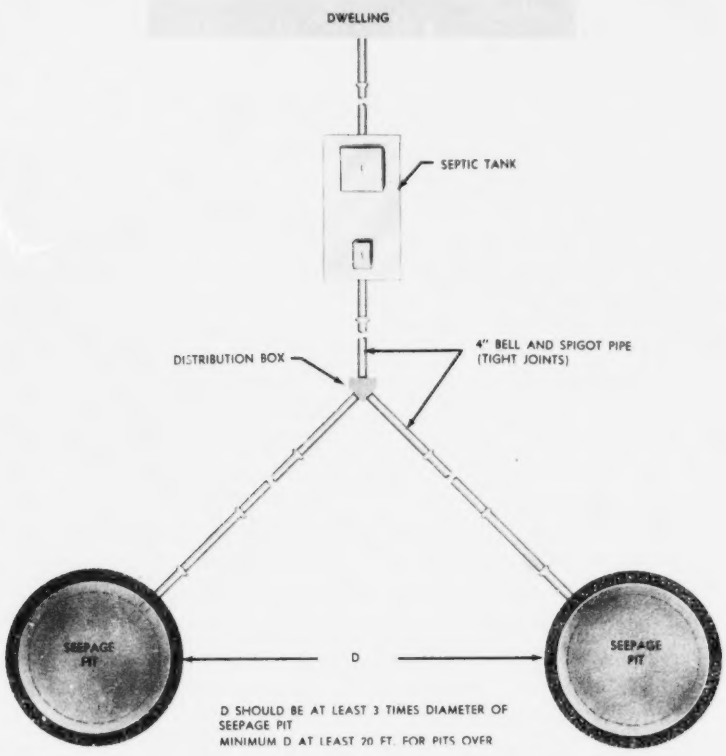

DWELLING
SEPTIC TANK
DISTRIBUTION BOX
4" BELL AND SPIGOT PIPE (TIGHT JOINTS)
SEEPAGE PIT
D
SEEPAGE PIT
D SHOULD BE AT LEAST 3 TIMES DIAMETER OF SEEPAGE PIT
MINIMUM D AT LEAST 20 FT. FOR PITS OVER

Figure 10.—Disposal system using two seepage pits.

joints or otherwise strengthened. Hard-burned brick, heavyweight concrete block, structural clay tile, and fieldstone are acceptable, if properly laid to provide necessary structural strength. If cored units are used, the cores should be laid in the vertical plane. Whatever the material, the walls should be laid close with no conscious attempt to provide openings between the units. The unevenness of the edges will provide all of the space necessary for the sewage to seep into the surrounding soil. Large openings invite trouble; they make the walls less stable structurally, and permit easier infiltration of the surrounding soil. Pits with large wall openings may be more likely to cave in or collapse than pits with closely built walls. The annular opening between the seepage-pit lining and the surrounding earth should be filled with coarse gravel.

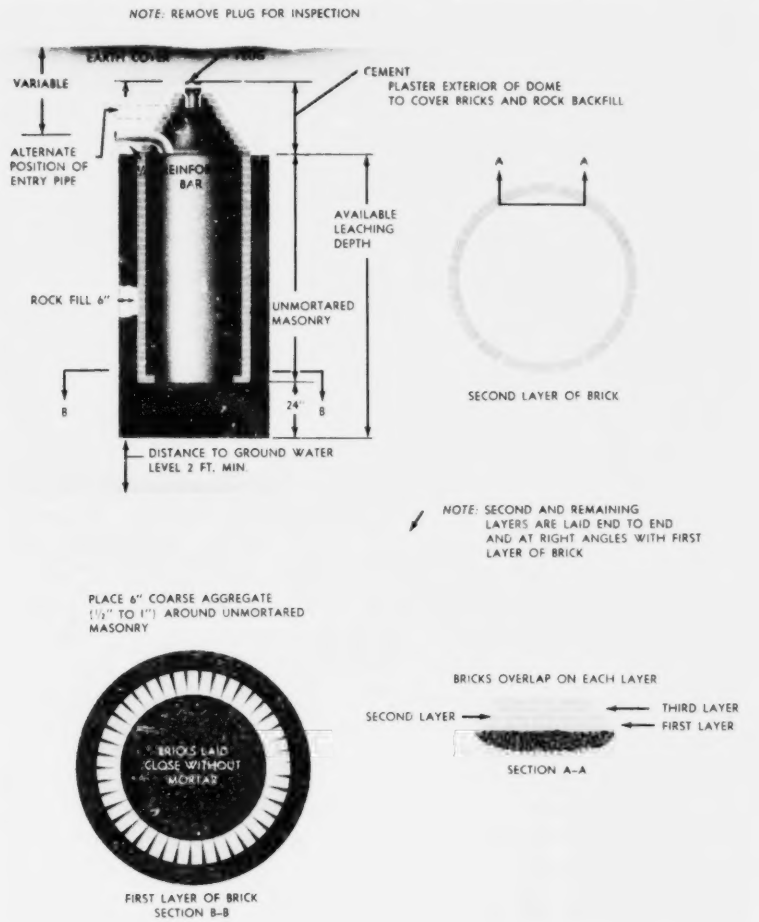


Figure 11.—Seepage pit.

In the construction of a seepage pit, it is particularly important that proper precautions be taken to prevent the side walls from collapsing while workmen are in the hole. Fatal accidents have occurred when this basic safety measure has not been observed. A common method of affording proper protection to the workmen is through the use of sheeting formed by semicircular sections of corrugated metal, braced with semicircular compression rods which are bolted on the inside with expansion bolts. In another type of seepage-pit construction, the walls are made of precast reinforced concrete sections with slotted holes. For deep seepage pits, or where there is any danger of caving, the sections are installed as the excavation progresses, and are used as the necessary protective sheeting.

Inspection before backfilling of new seepage pit installations is as important as in absorption-field construction.

Abandoned seepage pits should be filled with earth or rock.

SELECTION OF A SEPTIC TANK

Assuming that the lot will be large enough to accommodate one of the types of leaching systems, and that construction of the system is permitted by local authority, the next step will be selection of a suitable septic tank.

Functions of Septic Tanks

Untreated liquid household wastes (sewage) will quickly clog all but the most porous gravel formations. The tank conditions sewage so that it may be more readily percolated into the subsoil of the ground. Thus, the most important function of a septic tank is to provide protection for the absorption ability of the subsoil. Three functions take place within the tank to provide this protection.

1. *Removal of Solids.*—Clogging of soil with tank effluent varies directly with the amount of suspended solids in the liquid. As sewage from a building sewer enters a septic tank, its rate of flow is reduced so that larger solids sink to the bottom or rise to the surface. These solids are retained in the tank, and the clarified effluent is discharged.

2. *Biological Treatment.*—Solids and liquid in the tank are subjected to decomposition by bacterial and natural processes. Bacteria present are of a variety called anaerobic which thrive in the absence of free oxygen. This decomposition or treatment of sewage under anaerobic conditions is termed "septic," hence the name of the tank. Sewage which has been subjected to such treatment causes less clogging than untreated sewage containing the same amount of suspended solids.

3. *Sludge and Scum Storage.*—Sludge is an accumulation of solids at the bottom of the tank, while scum is a partially submerged mat of

floating solids that may form at the surface of the fluid in the tank. Sludge, and scum to a lesser degree, will be digested and compacted into a smaller volume. However, no matter how efficient the process is, a residual of inert solid material will remain. Space must be provided in the tank to store this residue during the interval between cleanings; otherwise, sludge and scum will eventually be scoured from the tank and may clog the disposal field.

If adequately designed, constructed, maintained, and operated, septic tanks are very effective in accomplishing their purpose.

The relative position of a septic tank in a typical subsurface disposal system is illustrated in Figure 7 (page 14). The liquid contents of the house sewer (A) are discharged first into the septic tank (B), thence to the distribution box (C), and finally into the subsurface absorption field (D).

The heavier sewage solids settle to the bottom of the tank, forming a blanket of sludge. The lighter solids, including fats and greases, rise to the surface and form a layer of scum. A considerable portion of the sludge and scum are liquefied through decomposition or digestion. During this process, gas is liberated from the sludge, carrying a portion of the solids to the surface, where they accumulate with the scum. Ordinarily, they undergo further digestion in the scum layer, and a portion settles again to the sludge blanket on the bottom. This action is retarded if there is much grease in the scum layer. The settling is also retarded because of gasification in the sludge blanket. Furthermore, there are relatively wider fluctuations of flow in small tanks than in the large units. This effect has been recognized in Table 4, below, which shows the recommended minimum liquid capacities of household septic tanks.

Septic tanks should be located where they cannot cause contamination of any well, spring, or other source of water supply. Underground contamination may travel in any direction and for considerable distances, unless filtered effectively. Underground pollution usually moves in the same general direction as the normal movement of the ground water in the locality. Ground water moves in the direction of the slope or gradient of the water table, i. e., from the area of high water table to areas of lower water table. In general, the water table follows the general contour of the ground surface. For this reason, septic-tanks should be located downhill from wells or springs. Sewage from disposal systems occasionally contaminate wells having higher surface elevations. Obviously, the elevations of disposal systems are almost always higher than the level of water in such wells as may be located nearby; hence, pollution from a disposal system on a lower *surface* elevation may still travel downward to the water-bearing stratum as shown in Figure 12, (page 23). It is necessary, therefore, to rely upon horizontal as well

as vertical distances for protection. Tanks should never be closer than 50 feet from any source of water supply; and greater distances are preferred where possible.

The septic tank should not be located within 5 feet of any building. The tank should not be located in swampy areas, nor in areas subject to flooding. In general, the tank should be located where the largest possible area will be available for the disposal field. Consideration should also be given to the location from the standpoint of cleaning and maintenance. Where public sewers may be installed at a future date, provision should be made in the household plumbing system for connection to such sewer.

Location.—Contrary to popular belief, septic tanks do not accomplish a high degree of bacteria removal. Although the sewage undergoes treatment in passing through the tank, this does not mean that infectious agents will be removed; hence, septic-tank effluents cannot be considered safe. The liquid that is discharged from a tank is, in some respects, more objectionable than that which goes in; it is septic and malodorous. This, however, does not detract from the value of the tank. As previously explained, its primary purpose is to condition the sewage so that it will cause less clogging of the disposal field.

Final purification of the effluent, including the removal of pathogens, is effected by percolation through the soil. Disease-producing bacteria will, in time, die out in the unfavorable environment afforded by soil. In addition, bacteria are also removed by certain physical forces during filtration. This combination of factors results in the eventual purification of the sewage effluent.

Table 4.—*Liquid capacity of tank (gallons)*

[Provides for use of garbage-grinders, automatic washers, and other household appliances]

Number of bedrooms	Recommended minimum tank capacity	Equivalent capacity per bedroom
2 or less	750	375
3	900	300
4 [1]	1,000	250

[1] For each additional bedroom, add 250 gallons.

Capacity.—Capacity is one of the most important considerations in septic-tank design. Studies have proved that liberal tank capacity is not only important from a functional standpoint, but is also good economy. The liquid capacities recommended in Table 4 allow for the use of all household appliances, including garbage-grinders.

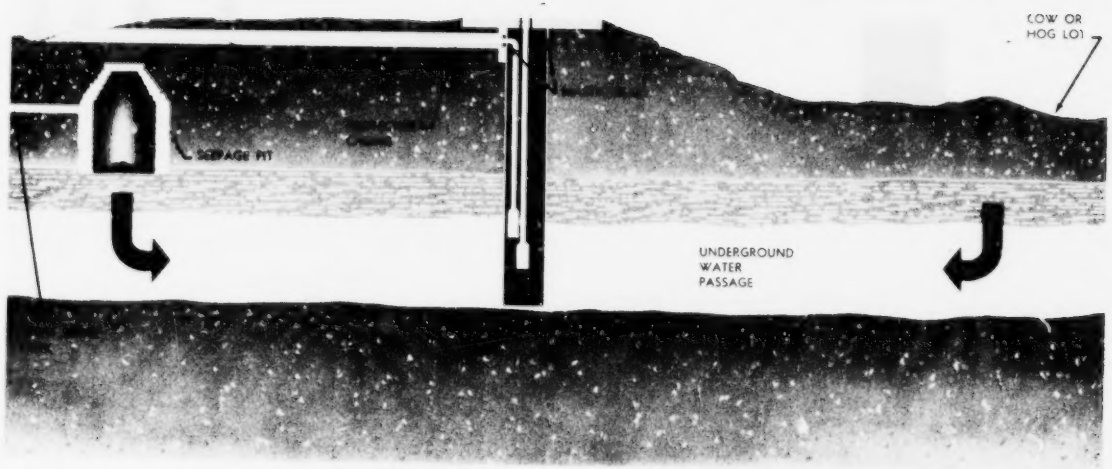


Figure 12.—Pollution of well from sources with lower surface elevations.

Specifications for Septic Tanks

General.—Septic tanks should be watertight and constructed of materials not subject to excessive corrosion or decay, such as concrete, coated metal, vitrified clay, heavyweight concrete blocks, or hard-burned bricks. Properly cured precast and cast-in-place reinforced concrete tanks are believed to be acceptable everywhere. Steel tanks meeting Commercial Standard 177–51 of the U. S. Department of Commerce are generally acceptable. Special attention should be given to job-built tanks to insure water tightness. Heavyweight concrete block should be laid on a solid foundation and mortar joints should be well filled. The interior of the tank should be surfaced with two ¼-inch-thick coats of portland cement-sand plaster. Some typical septic tanks are illustrated in figure 13 (page 25). Suggested specifications for watertight concrete are given in Appendix F.

Precast tanks should have a minimum wall thickness of 2½ inches, and should be adequately reinforced to facilitate handling. When precast slabs are used as covers, they should have a thickness of at least 3 inches and be adequately reinforced.

Backfill around septic tanks should be made in thin layers thoroughly tamped in a manner that will not produce undue strain on the tank. Settlement of backfill may be done with the use of water, provided the material is thoroughly wetted from the bottom upwards and the tank is first filled with water to prevent floating.

Adequate access must be provided to each compartment of the tank for inspection and cleaning. Both the inlet and outlet devices should be accessible. Access should be provided to each compartment by means of either a removable cover or a 20-inch manhole in least dimension. Where the top of the tank is located more than 18 inches below the finished grade, manholes and inspection holes should extend to approximately 8 inches below the finished grade (see Fig. 14, page 26). In most instances, the extension can be made using clay or concrete pipe, but proper attention must be given to the accident hazard involved when manholes are extended close to the ground surface. A typical single-compartment concrete tank is illustrated in Figure 15 (page 27).

Outlet.—It is important that the outlet device penetrate just far enough below the liquid level of the septic tank to provide a balance between sludge and scum accumulation; otherwise, part of the advantage of capacity is lost. A vertical section of a properly operating tank would show it divided into three distinct layers; scum at the top, a middle zone free of solids (called "clear space"), and a bottom layer of sludge. The outlet device retains scum in the tank, but at the same time, it limits the amount of sludge that can be accommodated without scouring, which results in sludge discharging in the effluent from the tank. Observations of sludge accumulations in the field, as reported in Section B Part III,

Figure 13.—Typical septic-tank shapes.

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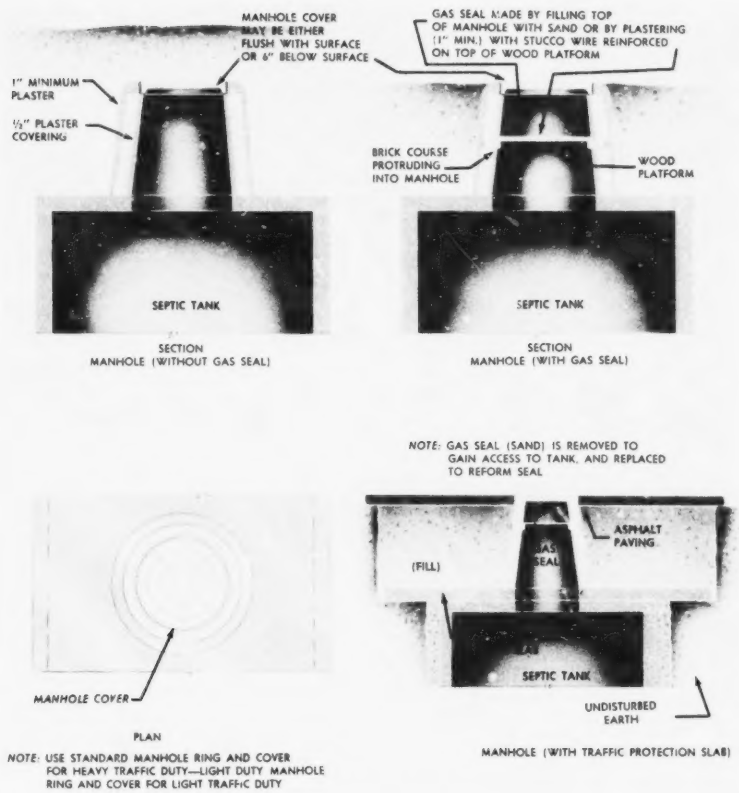
MANHOLE COVER MAY BE EITHER FLUSH WITH SURFACE OR 6" BELOW SURFACE
1" MINIMUM PLASTER
½" PLASTER COVERING
SEPTIC TANK
SECTION
MANHOLE (WITHOUT GAS SEAL)
GAS SEAL MADE BY FILLING TOP OF MANHOLE WITH SAND OR BY PLASTERING (1" MIN.) WITH STUCCO WIRE REINFORCED ON TOP OF WOOD PLATFORM
BRICK COURSE PROTRUDING INTO MANHOLE
WOOD PLATFORM
SEPTIC TANK
SECTION
MANHOLE (WITH GAS SEAL)
MANHOLE COVER
PLAN
NOTE: USE STANDARD MANHOLE RING AND COVER FOR HEAVY TRAFFIC DUTY—LIGHT DUTY MANHOLE RING AND COVER FOR LIGHT TRAFFIC DUTY
NOTE: GAS SEAL (SAND) IS REMOVED TO GAIN ACCESS TO TANK, AND REPLACED TO REFORM SEAL
ASPHALT PAVING
(FILL)
GAS SEAL
SEPTIC TANK
UNDISTURBED EARTH
MANHOLE (WITH TRAFFIC PROTECTION SLAB)

Figure 14.—Design of manholes.

of "Studies on Household Sewage Disposal Systems" (bibliography reference, page 85), indicate that the outlet device should generally extend to a distance below the surface equal to 40 percent of the liquid depth. For horizontal, cylindrical tanks, this should be reduced to 35 percent. For example, in a horizontal cylindrical tank having a liquid depth of 42 inches, the outlet device should penetrate 42 x .35 = 14.7 inches below the liquid level.

The outlet device should extend above the liquid line to approximately 1 inch from the top of the tank. The space between the top of the tank and the baffle allows gas to pass off through the tank into the house vent.

Inlet.—The inlet invert should enter the tank at least 1 inch (preferably 3 inches) above the liquid level in the tank, to allow for momentary rise in liquid level during discharges to the tank. This free drop prevents backwater and stranding of solid material in the house sewer leading to the tank.

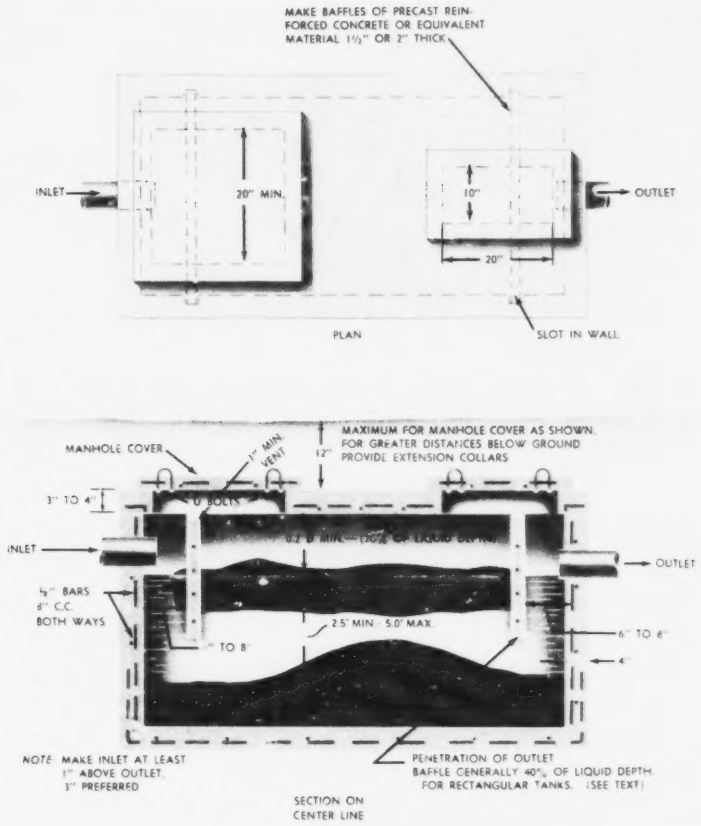
MAKE BAFFLES OF PRECAST REINFORCED CONCRETE OR EQUIVALENT MATERIAL 1½" OR 2" THICK
INLET
20" MIN.
10"
20"
OUTLET
PLAN
SLOT IN WALL
MANHOLE COVER
1" MIN. VENT
12"
MAXIMUM FOR MANHOLE COVER AS SHOWN. FOR GREATER DISTANCES BELOW GROUND PROVIDE EXTENSION COLLARS
3" TO 4"
"U" BOLTS
INLET
OUTLET
½" BARS 8" C.C. BOTH WAYS
2.5' MIN. - 5.0' MAX.
" TO 8"
6" TO 6"
4"
NOTE: MAKE INLET AT LEAST 1" ABOVE OUTLET, 3" PREFERRED
PENETRATION OF OUTLET BAFFLE GENERALLY 40% OF LIQUID DEPTH FOR RECTANGULAR TANKS. (SEE TEXT)
SECTION ON CENTER LINE

Figure 15.—Household septic tank.

A vented inlet tee or baffle should be provided to divert the incoming sewage downward. It should penetrate at least 6 inches below the liquid level, but in no case should the penetration be greater than that allowed for the outlet device. A number of arrangements commonly used for inlet and outlet devices are shown in Figure 16 (page 28).

Tank Proportions.—The available data indicate that, for tanks of a given capacity and surface area, shallower tanks function as well as deep ones. Also, for tanks of a given capacity and depth, the shape of a septic tank is unimportant. However, it is recommended that the smallest plan dimension be at least 2 feet. Liquid depth may range between 30 and 60 inches.

Storage Above Liquid Level.—Capacity is required above the liquid line to provide for that portion of the scum which floats above the liquid. Although some variation is to be expected, on the average about 30

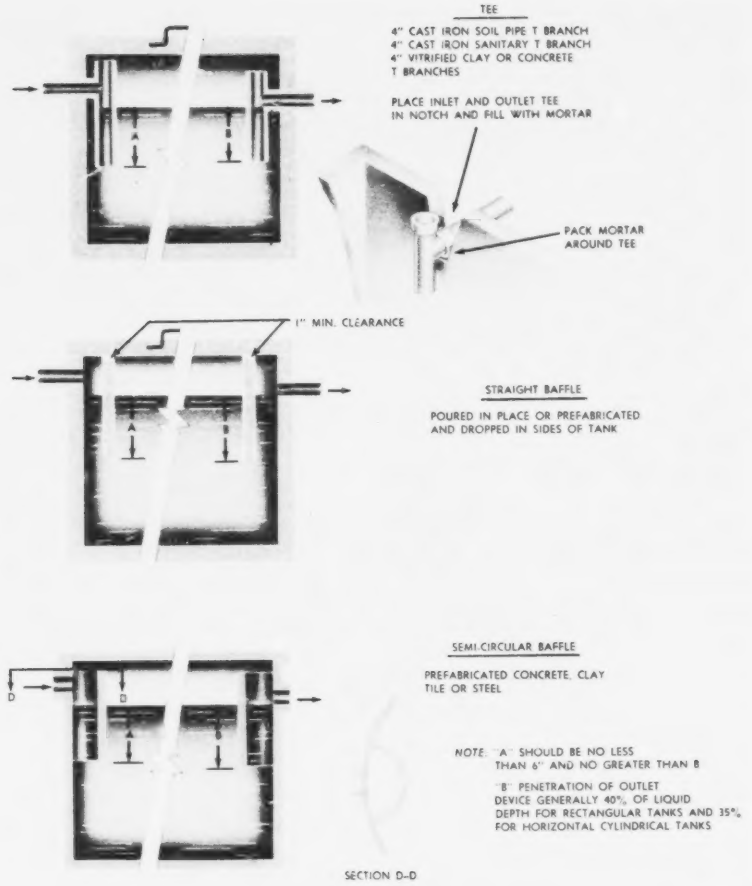

Figure 16.—Types of inlet and outlet devices.

percent of the total scum will accumulate above the liquid line. In addition to the provision for scum storage, 1 inch is usually provided at the top of the tank to permit free passage of gas back to the inlet and house vent pipe.

For tanks having straight, vertical sides, the distances between the top of the tank and the liquid line should be equal to approximately 20 percent of the liquid depth. In horizontal, cylindrical tanks, area equal to approximately 15 percent of the total circle should be provided above the liquid level. This condition is met if the liquid depth (distance from outlet invert to bottom of tank) is equal to 79 percent of the diameter of the tank.

Use of Compartments.—Although a number of arrangements are possible, the term "compartmentation," as used here, refers to a number of units placed in series. These can be either separate units linked together, or sections enclosed in one continuous shell (as in Figure 17), with watertight partitions separating the individual compartments (see page 30).

A single-compartment tank will give acceptable performance. The available research data indicate, however, that a two-compartment tank, with the first compartment equal to one-half to two-thirds of the total volume, provides an extra degree of suspended solids removal, which may be especially valuable under tight-soil conditions. Tanks with three or more equal compartments give at least as good performance as single-compartment tanks of the same total capacity. No tank should have an excess of four compartments, and each compartment shall have a minimum plan dimension of 2 feet with a liquid depth ranging from 30 to 60 inches.

An access manhole should be provided to each compartment. Venting between compartments should be provided to allow free passage of gas. Inlet and outlet fittings in the compartmented tank should be proportioned as for a single tank. (See Figure 16, page 28.) The same allowance should be made for storage above the liquid line as in a single tank.

General Information on Septic Tanks

Cleaning.—Septic tanks should be cleaned before too much sludge or scum is allowed to accumulate. If either the sludge or scum approaches too closely to the bottom of the outlet device, particles will be scoured into the disposal field and will clog the system. Eventually, when this happens, liquid may break through to the ground surface, and the sewage may back up in the plumbing fixtures. When a disposal field is clogged in this manner, it is not only necessary to clean the tank, but it also may be necessary to construct a new disposal field.

The tank capacities given in Table 4 will give a reasonable period of good operation before cleaning becomes necessary. There are wide differences in the rate that sludge and scum will accumulate from one tank to the next. For example, in one case out of 20, the tank will reach the danger point, and should be cleaned, in less than 3 years. Tanks should be inspected at least once a year and cleaned when necessary.

Although it is difficult for most homeowners, actual inspection of sludge and scum accumulations is the only way to determine definitely when a given tank needs to be pumped. When a tank is inspected, the depth of sludge and scum should be measured in the vicinity of the outlet baffle. The tank should be cleaned if either: (a) The bottom of the scum mat is within approximately 3 inches of the bottom of the outlet device; or (b) sludge comes within the limits specified in Table 5 (see Figure 18, page 32).

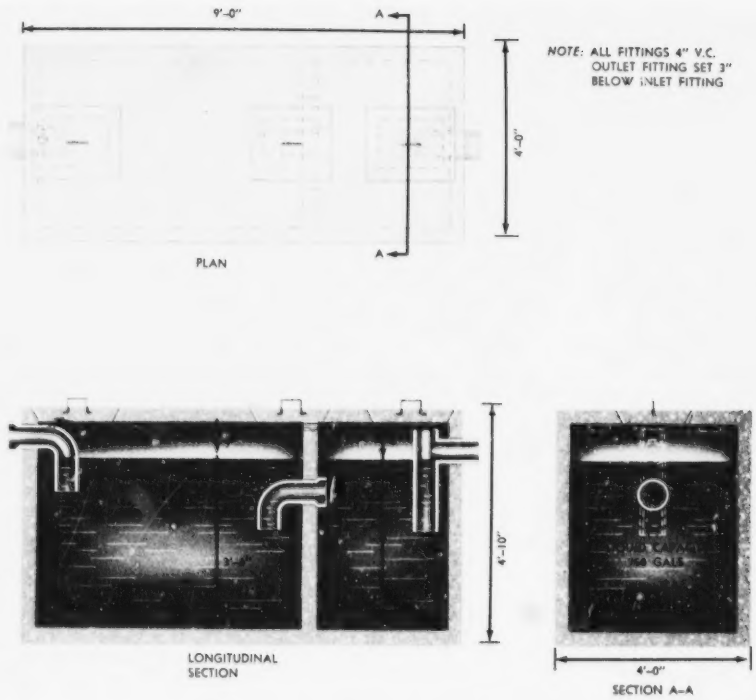

Figure 17.—Precast septic tank.

Table 5.—*Allowable sludge accumulation*

Liquid capacity of tank, gallons	Liquid depth		
	3 feet	4 feet	5 feet
	Distance from bottom of outlet device to top of sludge, inches		
500	11	16	21
600	8	13	18
750	6	10	13
900	4	7	10
1,000	4	6	8

Scum can be measured with a stick to which a weighted flap has been hinged, or with any device that can be used to feel out the bottom of the scum mat. The stick is forced through the mat, the hinged flap falls into a horizontal position, and the stick is raised until resistance from the bottom of the scum is felt. With the same tool, the distance to the bottom of the outlet device can be found (see Fig. 18, page 32).

A long stick wrapped with rough, white toweling and lowered to the bottom of the tank will show the depth of sludge and the liquid depth of the tank. The stick should be lowered behind the outlet device to avoid scum particles. After several minutes, if the stick is carefully removed, the sludge line can be distinguished by sludge particles clinging to the toweling.

In most communities where septic tanks are used, there are firms which conduct a business of cleaning septic tanks. The local health department can make suggestions on how to obtain this service. Cleaning is usually accomplished by pumping the contents of the tank into a tank truck. *Tanks should not be washed or disinfected after pumping.* A small residual of sludge should be left in the tank for seeding purposes. The material removed may be buried in uninhabited places or, with permission of the proper authority, emptied into a sanitary sewer system. It should never be emptied into storm drains or discharged directly into any stream or watercourse. Methods of disposal should be approved by the health authorities.

When a large septic tank is being cleaned, care should be taken not to enter the tank until it has been thoroughly ventilated and gases have been removed to prevent explosion hazards or asphyxiation of the workers. Anyone entering the tank should have one end of a stout rope tied around his waist, with the other end held above ground by another person strong enough to pull him out if he should be overcome by any gas remaining in the tank.

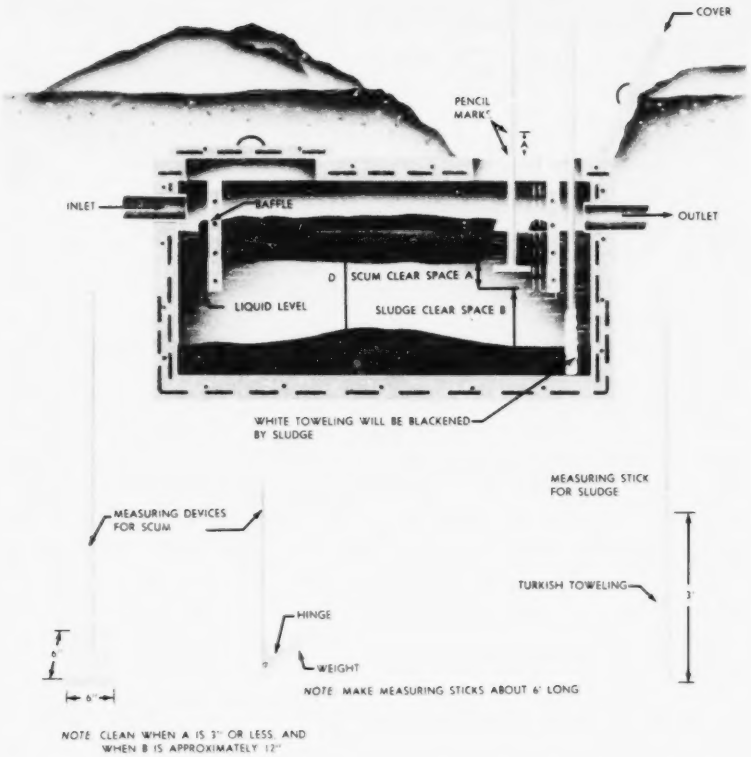

Figure 18.—Devices for measuring sludge and scum.

Grease Interceptors.—Grease interceptors (grease traps) are not ordinarily considered necessary on household sewage disposal systems. The discharge from a garbage-grinder should never be passed through them. The septic-tank capacities recommended in this manual are sufficient to receive the grease normally discharged from a home.

Chemicals.—The functional operation of septic tanks is not improved by the addition of disinfectants or other chemicals. In general, the addition of chemicals to a septic tank is not recommended. Some proprietary products which are claimed to "clean" septic tanks contain sodium hydroxide or potassium hydroxide as the active agent. Such compounds may result in sludge bulking and a large increase in alkalinity, and may interfere with digestion. The resulting effluent may severely damage

soil structure and cause accelerated clogging, even though some temporary relief may be experienced immediately after application of the product.

Frequently, however, the harmful effects of ordinary household chemicals are overemphasized. Small amounts of chlorine bleaches, added ahead of the tank, may be used for odor control and will have no adverse effects. Small quantities of lye or caustics normally used in the home, added to plumbing fixtures is not objectionable as far as operation of the tank is concerned. If the septic tanks are as large as herein recommended, dilution of the lye or caustics in the tank will be enough to overcome any harmful effects that might otherwise occur.

Some 1,200 products, many containing enzymes, have been placed on the market for use in septic tanks, and extravagant claims have been made for some of them. As far as is known, however, none has been proved of advantage in properly controlled tests.

Soaps, detergents, bleaches, drain cleaners, or other material, as normally used in the household, will have no appreciable adverse effect on the system. However, as both the soil and essential organisms might be susceptible to large doses of chemicals and disinfectants, moderation should be the rule. Advice of responsible officials should be sought before chemicals arising from a hobby or home industry are discharged into the systems.

Miscellaneous.—It is generally advisable to have all sanitary wastes from a household discharge to a single septic tank and disposal system. For household installations, it is usually more economical to provide a single disposal system than two or more with the same total capacity. Normal household waste including that from the laundry, bath, and kitchen, should pass into a single system.

Roof drains, foundation drains and drainage from other sources producing large intermittent or constant volumes of clear water should not be piped into the septic tank or absorption area. Such large volumes of water will stir up the contents of the tank and carry some of the solids into the outlet line; the disposal system following the tank will likewise become flooded or clogged, and may fail. Drainage from garage floors or other sources of oily waste should also be excluded from the tank.

Toilet-paper substitutes should not be flushed into a septic tank. Paper towels, newspaper, wrapping paper, rags, and sticks may not decompose in the tank, and are likely to lead to clogging of the plumbing and disposal system.

Waste brines from household water-softener units have no adverse effect on the action of the septic tank, but may cause a slight shortening of the life of a disposal field installed in a structured clay-type soil.

Adequate venting is obtained through the building plumbing if the tank and the plumbing are designed and installed properly. A separate vent on a septic tank is not necessary.

A chart showing the location of the septic tank and disposal system should be placed at a suitable location in dwellings served by such a system. Whether furnished by the builder, septic-tank installer, or the local health department, the charts should contain brief instructions as to the inspection and maintenance required. The charts should assist in acquainting homeowners of the necessary maintenance which septic tanks require, thus forestalling failures by assuring satisfactory operation. The extension of the manholes or inspection holes of the septic tank to within 8 inches of the ground surface will simplify maintenance and cleaning.

Abandoned septic tanks should be filled with earth or rock.

Part II

Septic-tank Systems for Institutions, Recreational Areas and Other Establishments

INTRODUCTION

The septic-tank system is utilized in providing sewage treatment and disposal for many types of establishments, such as schools, small institutions, motels, rural hotels and restaurants, trailer parks, housing projects, large private estates, and camps, where larger quantities of sewage are involved than are discharged from an individual home. Lack of competent sanitary-enginering advice in the development of such systems generally will lead to failures, excessive costs, and a multitude of troubles. The soundest advice available to anyone contemplating such a system is the early retention of competent sanitary-engineering consultation, whose first determination should be the suitability of this method of sewage disposal for the proposed establishment.

Any institutional septic-tank system must incorporate appurtenances and supplemental features of design to meet the requirements of the establishment and varying site conditions. These can be generally successful when appropriate experience, study, and planning are employed in the choice and development of such a system. This manual cannot present all of the results of experience gained in the design and operation of such systems, but describes the most generally successful procedures and practices as a guide to engineers designing them.

While many effluents from institutional septic tanks are disposed of by soil-absorption methods, others are discharged to available watercourses after suitable treatment. When soil-absorption methods are contemplated, it is essential, as described in Part I, to determine the characteristics and suitability of the soil as the first step toward design. As a matter of fact, the wise builder of an establishment will explore this feature on a contemplated site before the site is purchased. After the percolation tests are completed, the quantity of sewage to be treated must be estimated to determine the size and capacities of the disposal units.

ESTIMATES OF SEWAGE QUANTITIES

Where there are water meters in existing buildings, the quantity of sewage may best be estimated from the recorded meter readings.

In using water-meter readings for estimating the quantity of sewage to be contributed, some allowance should also be made for maximum conditions that may not be readily apparent from the readings. For example, water consumption by an ordinary family of four in an apartment building may average 48 gallons of water per person per day over a period of 3 months, but actually range from perhaps 30 gallons per person on certain days to something in excess of 80 gallons per person on days when water consumption is heaviest, as on washdays. Besides these peak loads, some allowance should be made for the sewage contributed by occasional guests. Therefore, when computing sewage flows from *average* meter readings, a minimum factor of safety of about 25 percent should be allowed to cover the range of variations. Accordingly, the design of a disposal system for the apartment house referred to, where the average usage is 48 gallons per person per day, should be based upon a computed maximum usage of at least 60 gallons per person per day.

Conversely, unusually high meter readings may be caused by lawn sprinkling or by leakage of water that does not enter the disposal system. Due allowances should be made for abnormalties of this kind.

Where measurements of water consumption are not possible, as where water-meter records are not available, or where disposal facilities are being planned for a new building, it is necessary to use other methods of estimating the amount of sewage to be discharged. One way is to base the computed flow on the number of bedrooms, as in Part I. Another way is to compute the flow on the basis of the number and kinds of plumbing fixtures. If the building is used as a restaurant, the number of patrons or the number of meals served may be the best criterion. The competent designer will base his estimates upon a combination of the various influencing factors. He will consider each case on its own merits, especially when disposal facilities are being designed for a large institution where the cost of construction will amount to a considerable sum. If definite information and accurate water measurements are not available, the quantity of sewage may be estimated from experiences at establishments similar to that for which the new sewage-disposal facilities are intended. Table 6 (page 37) may be helpful in such cases.

The quantities listed in the table are merely the best averages available at this time, and they should be modified in localities or establishments where experience indicates a need for so doing.

It is sometimes economical and advisable to construct separate disposal systems for different types of wastes at a given establishment. The decision as to the number of disposal systems may be influenced by conditions of terrain, topography, and locations of the buildings contribut-

ing to the wastes. At large camps, for example, and at some resorts, kitchens and central dining facilities may be located at appreciable distances from the barracks or cottages and cabins. Under such circumstances, the kitchens may be provided with separate disposal systems, including facilities for the removal of grease ahead of the septic tank.

Table 6.—*Quantities of sewage flow*

Type of establishment	Gallons per person per day
Small dwellings and cottages with seasonal occupancy	50
Single-family dwellings	75
Multiple-family dwellings (apartments)	60
Rooming houses	40
Boarding houses	50
Additional kitchen wastes for nonresident boarders	10
Hotels without private baths	50
Hotels with private baths (2 persons per room)	60
Restaurants (toilet and kitchen wastes per patron)	7 to 10
Restaurants (kitchen wastes per meal served)	2½ to 3
Additional for bars and cocktail lounges	2
Tourist camps or trailer parks with central bathhouse	35
Tourist courts or mobile home parks with individual bath units	50
Resort camps (night and day) with limited plumbing	50
Luxury camps	100 to 150
Work or construction camps (semipermanent)	50
Day camps (no meals served)	15
Day schools without cafeterias, gymnasiums, or showers	15
Day schools with cafeterias, but no gymnasiums or showers	20
Day schools with cafeterias, gyms, and showers	25
Boarding schools	75 to 100
Day workers at schools and offices (per shift)	15
Hospitals	150 to 250+
Institutions other than hospitals	75 to 125
Factories (gallons per person per shift, exclusive of industrial wastes)	15 to 35
Picnic parks (toilet wastes only), (gallons per picnicker)	5
Picnic parks with bathhouses, showers, and flush toilets	10
Swimming pools and bathhouses	10
Luxury residences and estates	100 to 150
Country clubs (per resident member)	100
Country clubs (per nonresident member present)	25
Motels (per bed space)	40
Motels with bath, toilet, and kitchen wastes	50
Drive-in theaters (per car space)	5
Movie theaters (per auditorium seat)	5
Airports (per passenger)	3 to 5
Self-service laundries (gallons per wash, i. e., per customer)	50
Stores (per toilet room)	400
Service stations (per vehicle served)	10

Separate systems may also be used for community bathhouses. When this is done, the total per capita flow must be broken down into its component parts, and some allowance should be made for the amount of sewage tributary to the different disposal systems. Table 7 (page 38) illustrates how this may be done where there are no definite data as to the exact distribution of flow.

Table 7.—*Estimated distribution of sewage flows, in gallons per day per person*

Type of waste	Volume, gallons per day per person				
Total Flow (gallons)	30	40	50	75	100
Kitchen wastes	[1] 0	7	10	10	15
Toilet wastes	15	15	20	25	30
Showers, washbasins, etc	15	18	20	25	35
Laundry wastes	[1] 0	[1] 0	[1] 0	15	20

[1] No wastes from these uses.

Example: In a household contributing 75 gallons of sewage per day per person, as shown in column 4, an average breakdown for each of the four types of wastes listed might be about 10 gallons per day per person for kitchen wastes; 25 gallons per day per person for toilet wastes; 25 gallons per day per person for shower wastes, bathtubs, and washbasins; and about 15 gallons per day per person for laundry wastes.

For certain types of new establishments, the designing engineer may be unable to obtain from his clients accurate estimates as to the number of patrons to be served by the disposal facilities. This is particularly true in the case of restaurants and at recreational places, such as picnic areas, country clubs, and the like. In such cases, computations and estimates may best be made from the number of plumbing fixtures installed. Table 8 indicates average values for quantities of sanitary wastes per fixture at country clubs with modern plumbing.

Table 8.—*Sewage flow from country clubs*

Type of fixture	Gallons per day per fixture	Type of fixture	Gallons per day per fixture
Showers	500	Toilets	150
Baths	300	Urinals	100
Lavatories	100	Sinks	50

Estimates of sewage quantities from golf clubs should be checked and calculations based on the weekend population. Allowances of 10 gallons per person for showers and 7 gallons per person for toilet and kitchen

wastes, both for the average weekend population, have been found reasonable.

Table 9 shows one method used in estimating the amount of sewage discharged hourly during the hours when public parks are open. Similar figures may be used for fairgrounds, carnivals, ball parks, etc.

Table 9.—*Sewage flow at public parks*

[During hours when park is open]

Type of fixture	Gallons per hour per fixture	Type of fixture	Gallons per hour per fixture
Flush toilets	36	Showers	150
Urinals	10	Faucets	15

ESTIMATES OF LEACHING AREAS

With information from percolation tests and with due consideration to the results of test borings or subsurface explorations, as explained in Part I and Appendix A, the rate at which sewage may be applied to a soil-absorption field may be taken from Table 10 or from the corresponding curve in Figure 19 (see page 40).

Table 10.—*Allowable rate of sewage application to a soil-absorption system*

Percolation rate (time in minutes for water to fall 1 inch)	Maximum rate of sewage application (gallons per square foot per day) [1] for standard trenches [2] and seepage pits [3]	Percolation rate (time in minutes for water to fall 1 inch)	Maximum rate of sewage application (gallons per square foot per day) [1] for standard trenches [2] and seepage pits [3]
1 or less	5.0	10	1.6
2	3.5	15	1.3
3	2.9	30 [4]	0.9
4	2.5	45 [4]	0.8
5	2.2	60 [4 5]	0.6

[1] Not including effluents from septic tanks that receive wastes from garbage-grinders and automatic washing machines.

[2] Absorption area for standard trench is figured as trench-bottom area.

[3] Absorption area for seepage pits is effective side-wall area.

[4] Over 30 unsuitable for seepage pits.

[5] Over 60 unsuitable for leaching systems.

Table 10 and the curves in Figure 19 do not allow for wastes from garbage-grinders and automatic washing machines. Discharge from these appliances to an institutional septic-tank system calls for extra capacity of 20 and 40 percent, respectively, over the calculated leaching-area values. If both of these appliances are installed, the leaching area should be increased by about 60 percent over the calculated value. Part I allowed for these types of waste in giving specifications for small household systems, but they may never occur in institutional effluents, such as those from factories and offices. Other institutions, such as a country club or drive-in theatre with eating facilities, may contribute wastes from garbage-grinders, but not from automatic washing machines. As previously emphasized, all institutions should have their systems designed by an engineer who is competent to place proper evaluations on the kind of wastes to be contributed.

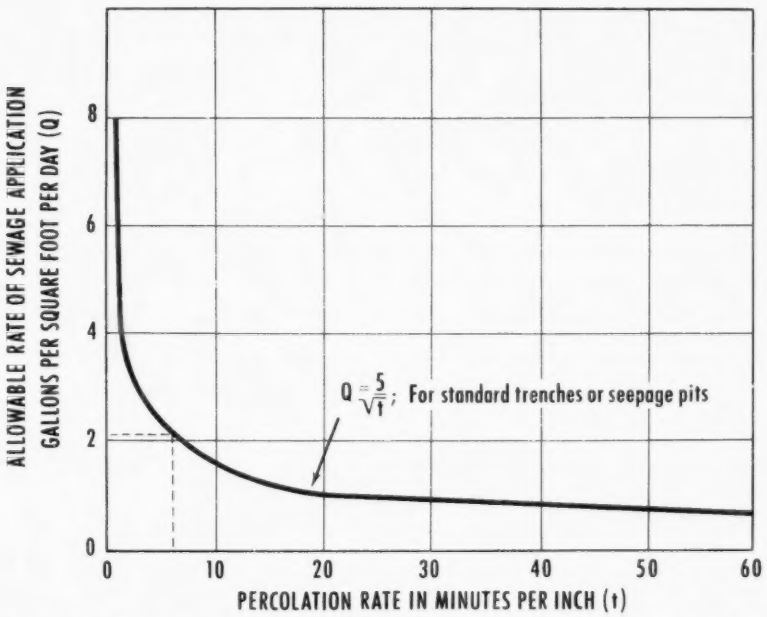

Figure 19.—Graph showing relation between percolation rate and allowable rate of sewage application.

Use of Table 10 is demonstrated in the following examples, which illustrate the design for the two types of soil absorption systems. For each example assume: 5,000 gallons of sewage per day to be disposed of; percolation rate, 1 inch in 5 minutes.

EXAMPLE I.—Absorption Trenches:

Standard trench, 2 feet width.

5,000 gal./day ÷ 2.2 gal./sq. ft./day = 2,270 square feet of absorption area required.

2,270 ÷ 2 sq. ft./linear ft. = 1,135 feet of trench required.

With garbage-grinder only—1,135 + .20 (1,135) = 1,362 linear feet.

With automatic washing machine only—1,135 + .40 (1,135) = 1,589 linear feet.

With garbage-grinder and automatic washing machine—1,135 + .60 (1,135) = 1,816 linear feet.

EXAMPLE II.—Seepage Pits:

Seepage Pit, 10-foot diameter: depth of effective absorption area 25 feet; let x = depth of pit in feet; D equal pit diameter in feet. Effective sidewall area equals total area needed.

$\pi D(x) = 2270$ sq. ft.

3.14 (10) (x) = 2270.

Solve for x, depth of pit = 72 ft.

Obviously, more than one pit is required.

Design for 3 pits, 10 ft. in diameter.

72 ÷ 3 = 24 ft.

Use 3 pits, 10 ft. in diameter and 24 ft. deep.

With garbage-grinder only—3.14 (10) (x) = 2270 + 2270 (.20) = 2724 sq. ft. Solve for x = 86.4 ft. Use 4 pits, 10 ft. in diameter and 21.6 ft. deep.

With automatic washing machine only—3.14 (10) (x) = 2270 + 2270 (.40) = 3178 sq. ft. Solve for x = 101 ft. needed. Use 5 pits, 10 ft. in diameter and 20.2 ft. deep.

With garbage-grinder and automatic washing machine—3.14(10) (x) = 2270 + 2270 (.60) = 3632 sq. ft. required. Solve for x = 115.7 ft. required. Use 5 pits, 10 ft. in diameter and 23.1 ft. deep.

BUILDING SEWERS

The building sewer or house sewer is the pipeline carrying sewage from the building or house drain to a private sewer, public sewer, septic tank, or other point of disposal. It usually extends from a point 2 or 3 feet outside the building, where it is connected to the building drain.

The building sewer should be constructed of cast iron, vitrified clay, concrete, bituminized fiber, asbestos cement, or other durable material. All joints in the sewer line should be watertight and rootproof. The grade of the building sewer should be at least 2 percent (2-foot fall per 100 feet, or ¼-inch per foot) except for the 10 feet immediately preceding the septic tank, where it should not exceed 2 percent. Buildings should be planned so that a proper slope of the building sewer can be obtained. Where the terrain is extremely flat, however, it may be advisible to allow a slope of only 6 inches per 100 feet, or 0.5 percent (see Table 11, page 42).

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The size of the pipeline to a septic tank is generally dependent upon its ability to allow objects to pass, and upon its capacity to conduct high flows for short periods, rather than upon its capacity in relation to the average flow. No building sewer serving water closets should be less than 4 inches in size. The relationship of minimum sizes to the slopes and to the number of fixtures is indicated in Table 11.

Table 11.—*Maximum number of fixture units[1] served by building sewer of indicated size and slope*

Minimum pipe diameter, inches	Pipe slope (inch per foot)			
	3/16	1/8	1/4	1/2
4	.....	180	216	250
5	.....	390	480	575
6	.....	700	840	1,000
8	1,400	1,600	1,920	2,300
10	2,500	2,900	3,500	4,200
12	3,900	4,600	5,600	6,700

[1] A fixture unit is a quantity in terms of which the load-producing effects of different plumbing fixtures on the plumbing system are expressed on some arbitrarily chosen scale. For example, a small lavatory is rated as 1 fixture unit; a kitchen sink, 2; a bathtub, 2; a tank-operated water closet, 4; and a valve-operated water closet, 8. A table of ratings from the American Standard National Plumbing Code is given in Appendix E, page 81.

Cleanouts should be provided at the junction of the building drain and building sewer and at each change in direction of the building sewer. They should also be provided at intervals of not more than 50 feet on lines of 4-inch diameter, or 100 feet in larger pipes.

That portion of the sewer line within 10 to 50 feet of any well or suction line from a well, or within 10 feet of any drinking-water supply line under pressure, or within 5 feet of any basement foundation, should be made of cast iron with leaded joints. Cast iron should also be required wherever the line crosses under driveways with less than 3 feet of earth cover. While no general statement can be made to cover all cases, it is suggested that no sewer line pass within 25 feet of a well or other source of water supply, and that all sewers within 50 feet of such sources of water supply be of cast-iron pipe with watertight joints. Where sewer lines are in the vicinity of trees or dense shrubs, and are not constructed of cast iron as indicated above, the joint should be made of special, root-resistant construction.

Bends ahead of the septic tank should be limited to 45° or less wherever possible. If 90° bends cannot be avoided, they should be made with two 45° ells, or a long-sweep quarter curve or bends.

COLLECTION SYSTEMS

At institutions where there are a number of buildings, it may be advisable to provide a system of sewers for the collection, transportation, and possibly the pumping of sewage to the septic tank. In general, the collection system should be designed for a capacity expected to be adequate for at least one decade, and preferably two. It is usually advisable to design the sewers with capacities, when running full, of not less than 10 times the average estimated flow of sewage.

Institutional sewers carrying raw or untreated sewage should be at least 6 inches in diameter and have slopes of at least ⅛ inch to the foot (1.0 percent). In very small installations, 4-inch sewers at ¼ inch per foot (2 percent) may be used to carry raw sewage, and 4-inch sewers with slopes of ⅛ inch per foot are acceptable for carrying settled sewage. In general, all sewers should be designed with hydraulic slopes that will give mean velocities, when flowing full or half full, of not less than 2.0 feet per second, based on Kutter's or Manning's formula. For 8-inch or larger sewers, velocities should be determined by using a value of "n"=0.013 for pipe in 2-foot to 4-foot lengths, "n"=0.0125 for any smooth and durable pipe in 5-foot to 10-foot lengths, and "n"=0.012 for smooth and durable pipe in lengths of 11 feet or greater.

Under exceptional conditions, if full and justifiable reasons are given, and if special arrangements are available or will be provided for flushing, velocities as low as 1.6 feet per second may be permitted. In general, the following minimum grades should be provided:

	Percent
8-inch sewers	0.40
10-inch sewers	0.28
12-inch sewers	0.22

The use of a larger sewer to take advantage of the lesser minimum slope, when there is not enough sewage to fill the sewer nearly one-half full, is generally not advisable. The use of asbestos-cement pipe or enamel-lined or cement-lined cast-iron pipe is suggested under such conditions.

Sewer lines must be laid on straight alignment and uniform slope between manholes. Manholes should be placed on sewers at all points of change of slope or alignment, at the upper ends of all sewer lines, and otherwise at intervals not greater than 400 feet. If the topography is very uneven and frequent changes in alignment and slope are necessary, a limited number of lampholes may be substituted for manholes at such points of change. Not more than one lamphole should be placed between two successive manholes.

There must be no permanent physical connection between a public or private potable-water supply system and a sewer, sewage-disposal system, or appurtenances thereto, which would render possible the passage of any sewage or polluted water into the potable-water supply.

GREASE TRAPS

Premature failures of septic-tank systems are sometimes due to accumulations of grease within the tanks. Sewer lines frequently clog because of grease collections. When grease traps are used, the grease must be removed at frequent intervals. Grease traps may be used on kitchen wastelines from institutions, hotels, restaurants, schools with lunchrooms, and other places where the volume of kitchen wastes is large. After passing through the grease trap, the kitchen wastes must still be treated in the septic tank before being discharged to the disposal area. Wastes from garbage-grinders should not be discharged to a grease trap. (Grease traps have been used with some degree of success for the removal of lints and fines from laundry wastes, but better results may be obtained by increasing the size of the septic tanks receiving such wastes, or by the use of rock filters to remove the lint.)

Location

Grease traps should be placed at a location that is readily accessible for cleaning, and close to the fixture discharging greasy wastes.

Construction Details

The most important considerations for design of grease traps are:

1. Capacity of the trap.
2. Facilities for insuring that both the inlet and outlet are properly trapped.
3. Ease and convenience with which the traps can be cleaned and the accumulated grease removed.
4. Inaccessibility of the traps to insects and vermin.
5. Distance between inlet and outlet, which should be sufficient to allow gravity-differential separation of the grease, so that it will not escape through the outlet.

The principles are illustrated in figure 20 (page 45).

Flow-control fittings should be installed on the inlet side of smaller traps to protect against overloading or sudden surges from the sink or other fixtures. Venting is not necessary in the large, outdoor traps, where siphonage of the contents can be prevented by providing outlets of liberal size. Where efficient removal of grease is very important, use has been made of an improved 2-chamber trap which has a primary (or grease-separating) chamber and a secondary (or grease-storage) chamber. By placing the trap as close as possible to the source of wastes, where the wastes are still hot, the separating grease at the surface may be removed by means of an adjustable weir and conveyed to the separate secondary chamber, where it accumulates, cools, and solidifies.

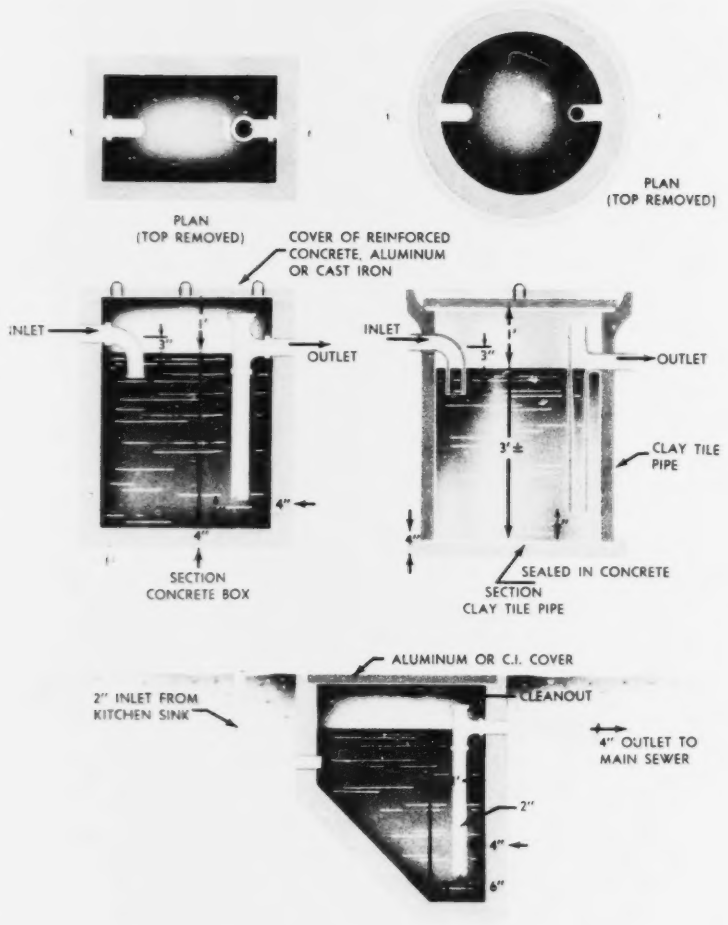

Figure 20.—Typical grease traps.

Capacity

Selection of size of traps should be based on verified efficiency ratings and flow capacities. The required flow capacities should be based upon the number and kind of sinks or fixtures discharging to the trap. In addition, a grease trap should be rated on its accumulated-grease capacity, which is the amount of grease (in pounds) that the trap can hold before its average efficiency drops below 90 percent. It is commonly regarded that the grease-retaining capacity in pounds should equal at least twice the flow rating in gallons per minute. That is to say, a trap rated at 20 g. p. m. should retain at least 90 percent of the grease dis-

charged to it until it holds at least 40 pounds of grease. Most manufacturers of commercial traps rate their products in accordance with this procedure.

Recommended minimum flow-rate capacities of traps connected to different types of fixtures is given in Table 12 (page 46).

Table 12.—*Recommended ratings for commercial grease traps*

Type of fixture	Rate of flow, in g. p. m.	Grease retention capacity rating, in pounds	Recommended maximum capacity of fixture connected to trap, in gallons
Restaurant kitchen sink	15	30	37. 5
Single-compartment scullery sink	20	40	50. 0
Double-compartment scullery sink	25	50	62. 5
2 single-compartment sinks	25	50	62. 5
2 double-compartment sinks	35	70	87. 5
Dishwashers for restaurants:			
Up to 30 gal. water capacity	15	30	37. 5
30 to 50 gal. water capacity	25	50	62. 5
50 to 100 gal. water capacity	40	80	100. 0

A net capacity of 2½ gallons per person has been found large enough to hold the flow from one meal long enough to accomplish proper grease separation. The minimum allowable capacity should be about 125 gallons for small installations serving up to about 50 people with proportionately larger capacities for larger populations. As with septic tanks, however, it is generally good economy to build grease traps somewhat oversize. For installations too small to justify a 125-gallon grease trap, best results can usually be obtained by applying available funds to an oversized and properly fitted septic tank.

Operation

In order to be effective, grease traps must be operated properly and cleaned regularly to prevent the escape of appreciable quantities of grease into the septic tank. The frequency of cleaning at any given installation can best be determined by experience based on observation over selected typical periods of use. Generally, cleaning should be done when 75 percent of the grease-retention capacity is filled with accumulated grease.

Grease traps must be kept tightly covered to prevent odor nuisances and to exclude insects and vermin. Grease removed from the traps is disposed of by burial. (It may be used for making soap and glycerine,

and for other manufacturing purposes, when economically feasible or because of shortages of such materials during wartime.)

SEPTIC TANKS FOR INSTITUTIONAL SYSTEMS

As explained in Part I, septic tanks of two compartments give better results than single-compartment tanks. Although single-compartment tanks are acceptable for small household installations, tanks with two or more compartments should be provided for the larger institutional systems. Tanks with more than two compartments are installed infrequently.

The compartments should be separated by walls containing ports or ell fittings at proper elevations. In the selection of these elevations, the same general principles apply as in the design of outlet fittings. Vents for the passage of gases from one compartment to another should also be included.

In a two-compartment tank, the compartment nearest the outlet is used both as a settling basin and as an observation well. The relative absence of solid material in the second compartment serves as an indication that the tank is functioning properly, although it may not serve as an index of conditions within the first compartment, and it is sometimes advisable to clean the first compartment before accumulations in the second become appreciable. In a two-compartment tank, the first compartment should have a capacity at least two to three times the capacity of the second compartment.

Whatever the number of compartments, means should be provided for gaining access to each compartment, and for measuring the depths of sludge and scum at the outlet device as illustrated in figure 18 (page 32). Unless tops of septic tanks are near the surface of the ground, as in figure 15 (page 27), manholes should be provided as required to facilitate ingress and egress. A single manhole above a dividing wall may be used for gaining access to two compartments in a multicompartment tank. Manholes are also desirable over the inlet and outlet devices.

Alternate designs for manholes are shown in figure 14 (page 26). The design selected will depend on whether or not the manhole cover must be flush with the surface, and on the anticipated traffic loadings over the area.

The effect of a multiple-compartment tank can be accomplished by using two or three tanks in series. A better construction arrangement, particularly for medium or large installations, is to connect special tank sections together into a unit having single end-walls and two compartments. A unit of four precast tank sections forming two compartments is shown in figure 21 (page 48). For operational reasons, it is recommended that the number of compartments or tanks in series be limited to four.

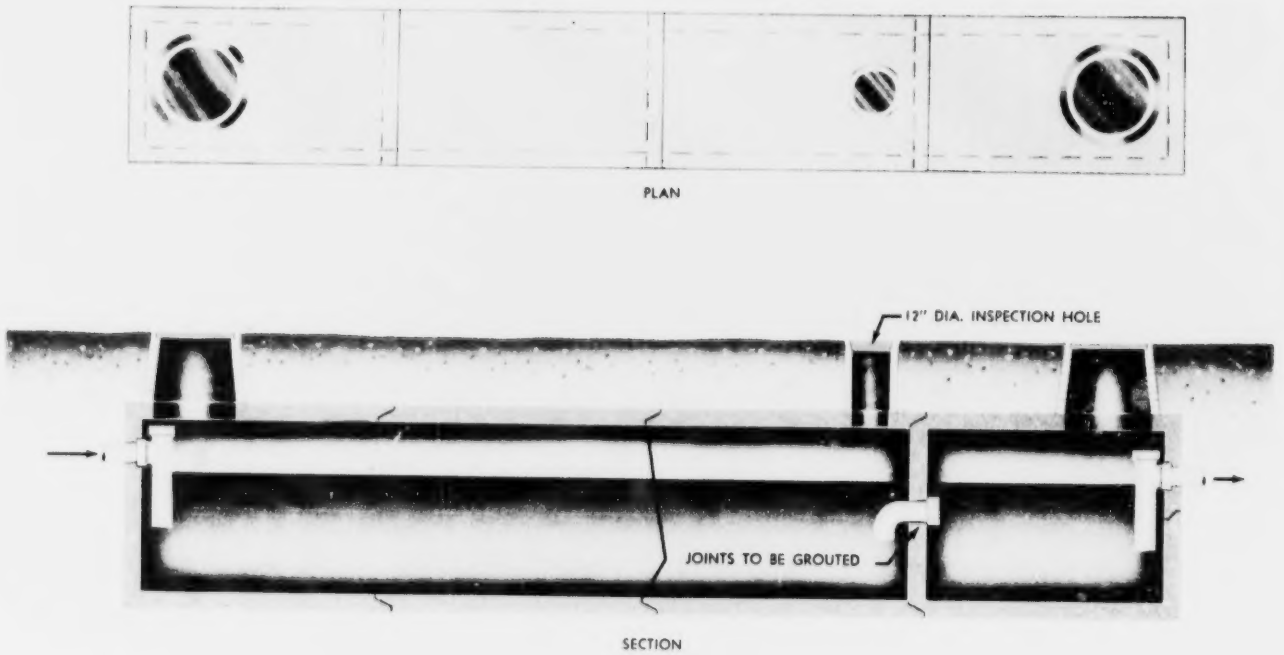

Figure 21.—Battery of four precast reinforced-concrete septic-tank sections.

Capacities

The net volume or effective capacity below the flowline of a septic tank, for flows up to 500 gallons per day, should be at least 750 gallons. For flows between 500 and 1500 gallons per day, the capacity of the tank should be equal to at least 1½ days' sewage flow. With flows greater than 1500 gallons per day, the minimum effective tank capacity should equal 1125 gallons plus 75 percent of the daily sewage flow; or

$$V = 1125 + 0.75Q$$

where V is the net volume of the tank in gallons and Q is the daily sewage flow in gallons. Recommended tank capacities for flows up to 14,500 gallons per day may also be obtained from figure 22 (page 49). For higher flows of up to about 100,000 gallons per day, Imhoff tanks may be more satisfactory than septic tanks for primary treatment. For flows above 100,000 gallons, still other types of sedimentation tanks may be more economical. These fall within the category of design for municipal systems, and are beyond the scope of this manual.

DOSING TANKS

When the quantity of sewage exceeds the amount that can be disposed of in about 500 lineal feet of tile, a dosing tank should be used in con-

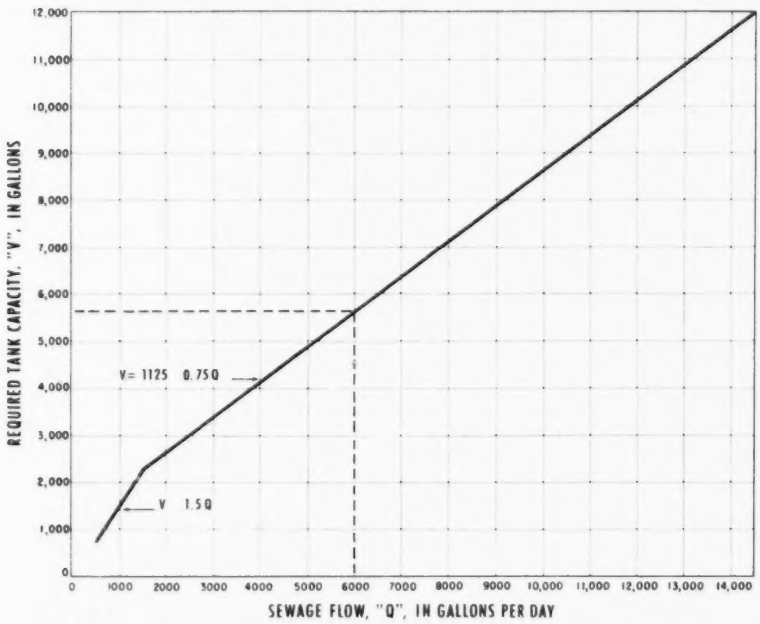

Figure 22.—Septic-tank capacities for sewage flows up to 14,500 gallons per day.

junction with the septic tank, in order to obtain proper distribution of sewage throughout the disposal area and give the absorption bed a chance to rest or dry out between dosings. Rest periods are always advantageous, especially when the soil is dense. The dosing tank should be equipped with an automatic siphon which discharges the tank once every 3 or 4 hours. The tank should have a capacity equal to about 60 to 75 percent of the interior capacity of the tile to be dosed at one time.

Where the total length of tile laterals exceeds 1,000 feet, the dosing tank should generally be provided with two siphons dosing alternately and each serving one-half of the tile field. The proper design of dosing devices involves hydraulic problems and head losses which must be carefully considered. Dosing siphons require operating heads ranging from about 5 feet down to a minimum of 1 or 2 feet, and repeated studies of different layouts may be necessary in order to arrive at an economical design in which available head is conserved and best use is made of existing conditions of topography. Special siphons are manufactured for low head losses. For details and capacities, the manufacturers' bulletins should be consulted.

Special care must be taken in the installation of siphons. All dimensions and elevations should be carefully followed, and no changes should be made without prior approval by the engineer or manufacturer. Tests should be made to determine that there are no air leaks, either in the piping or bell casting, and if leaks are found, they should be repaired. Leaks may be detected by filling the dosing tank with water, to a point where the bell and piping connections are covered, and observing the water surface for rising bubbles. New siphons should be primed by filling with water when the system is first started anyway, and the tests for leakage can be made at that time.

When properly installed, automatic dosing siphons will give satisfactory service. The contain no moving parts and are more foolproof than any dosing device that depends upon moving parts for its operation. Figure 23 (page 51) shows a septic tank and dosing compartment with alternating siphons, as illustrated in suggested plans and designs developed by a State health department.

A typical layout plan or "general plan" of a system using alternating siphons is illustrated in Figure 24 (page 52).

Separate siphon compartments already equipped with siphons are made by some manufacturers. Duplex siphon compartments equipped with two siphons which operate alternately are also prefabricated.

If the head available is inadequate to permit the use of a siphon, intermittent pump operation may be used to obtain proper dosing of the field, as shown in Figure 25 (page 53). The pump discharge lines may be cross-connected to obtain flexibility and to facilitate operations when one pump is down for repairs.

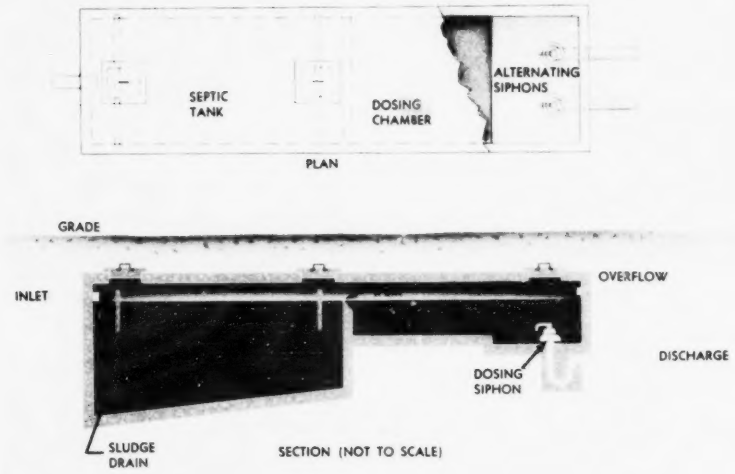

Figure 23.—Septic tank and dosing tank with alternating siphons.

SAND-FILTER TRENCHES

In permeable soil, absorption trenches of the type illustrated in Figure 6 (page 11), or seepage pits as illustrated in Figure 11 (page 19), provide the best underground method of disposing of the effluent from a septic tank. The absorption trench is preferred, and is required in some areas where seepage pits are prohibited. In soil that is relatively impermeable, however, neither absorption trenches nor seepage pits are satisfactory. They become more expensive as the soil permeability decreases, and may not be economically feasible when the percolation time exceeds 30 or 40 minutes per inch. The exact point at which they are no longer desirable will depend largely upon the relative costs of labor and material in the locality where the disposal system is to be constructed. The decision as to whether to use absorption trenches or seepage pits may also depend upon the area available. Where land is at a premium, absorption trenches become less attractive. They begin to require excessive areas when the percolation time exceeds 20 minutes per inch.

When absorption trenches and seepage pits are impractical for institutional or similar use, the possibility of treating the tank effluent in subsurface sand-filter trenches may be considered.

The filter trenches are somewhat similar to absorption trenches, the major difference being that the filter trenches are deeper, generally somewhat wider, contain an intermediate layer of sand as filtering material, and are provided with underdrains for carrying off the filtered sewage. The tank effluent is not absorbed, except to a limited extent. It is simply filtered and must be disposed of when it leaves the trench. For this

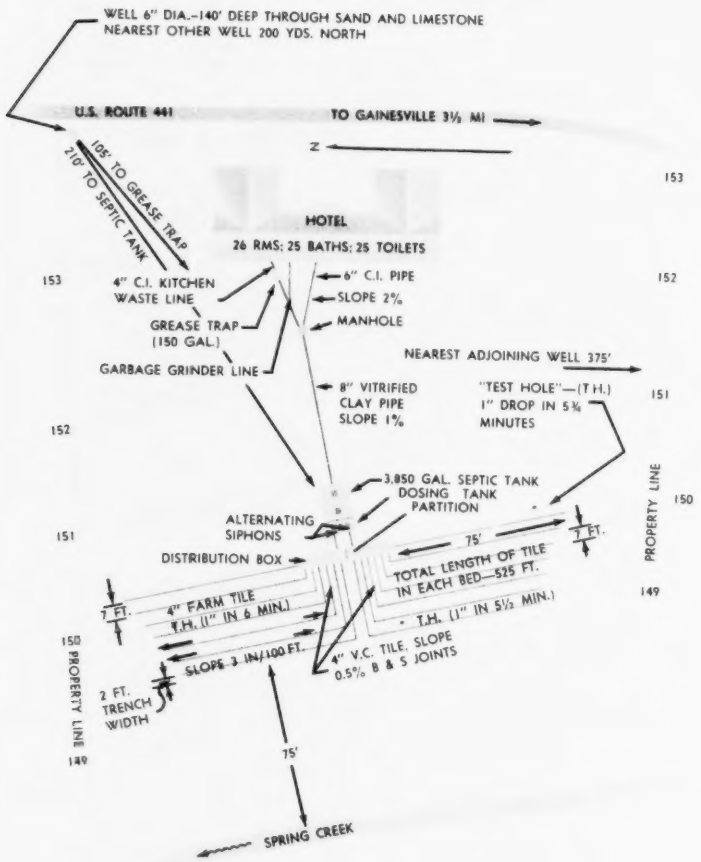

Figure 24.—Typical layout plan of a subsurface sewage-disposal system.

DESIGN DATA FOR DISPOSAL SYSTEM ILLUSTRATED IN FIGURE 24

Hotel

26 rooms total	
20 rooms with private baths × 2 persons per room × 60 gal. per person per day	= 2,400 gal. per day
6 rooms with connecting baths × 2 persons per room × 50 gal. per person per day	= 600 gal. per day
5 daytime employees × 25 gal. per person per day	= 125 gal. per day
2 night employees × 25 gal. per person per day	= 50 gal. per day
Kitchen wastes: 60 persons × 3 meals per day × 2½ gal. per meal	= 450 gal. per day
Total daily sewage flow	= 3,625 gal. per day

Required septic-tank capacity (from Fig. 22)	3,850 gal.
Required grease-trap capacity 60 persons $\times 2\frac{1}{2}$ gal.	150 gal.
Percolation test: 6 min. per inch drop.	
Allowable rate of sewage application (from Fig. 19)	=2.1 gal. per sq. ft. per day
Trench area required for normal wastes $=\frac{3625}{2.1}$	=1,725 sq. ft.
Plus 20% additional for wastes from garbage grinder	345 sq. ft.
Total trench area required	2,070 sq. ft.
Desired trench width	=24 inches (2.0 ft.)
Total trench length	$=\frac{2070}{2}=1035$ ft.

Dosing tank, alternating siphons, and twin fields required.

$\frac{1035}{2}=518$ lineal ft. trench per field.

Maximum trench length 100 ft.; desired length 50–60 ft.
75 ft. lengths can best be worked into available disposal area with room for future additions if needed.

$\frac{518}{75}=7$ lines of (4″) laterals required for each field.

Preferred dosing-tank capacity=75 percent of interior capacity of tile to be dosed at one time.
4″ tile $=3.14\times 2^2\times 12=151$ cu. in. per ft.

$\frac{151 \text{ cu. in./ft.} \times 0.75}{231 \text{ cu. in./gal.}}=0.49$ ga/lft. required dosing-tank capacity (say 0.5)

Thus the capacity of the dosing tank should be 0.5 gal./ft. $\times 7\times 75$ ft. $=260$ gallons.

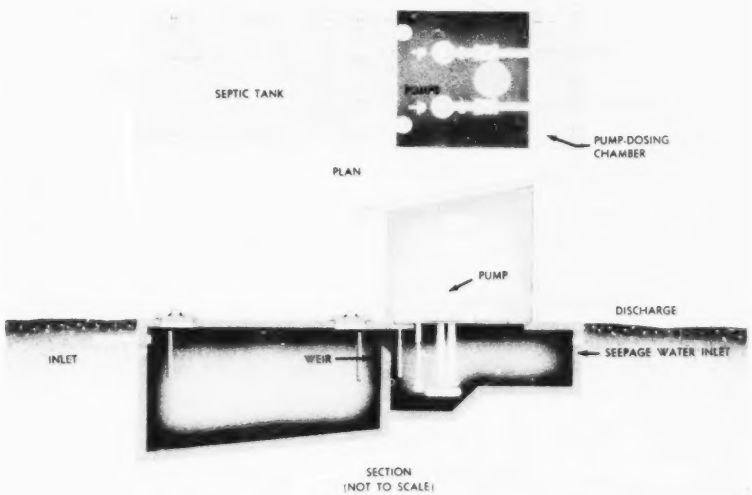

Figure 25.—Septic tank and pump-dosing chamber.

Required septic-tank capacity (from Fig. 22)	3,850 gal.
Required grease-trap capacity 60 persons×2½ gal.	150 gal.
Percolation test: 6 min. per inch drop.	
Allowable rate of sewage application (from Fig. 19)	=2.1 gal. per sq. ft. per day
Trench area required for normal wastes $=\frac{3625}{2.1}$	=1,725 sq. ft.
Plus 20% additional for wastes from garbage grinder	345 sq. ft.
Total trench area required	2,070 sq. ft.
Desired trench width	=24 inches (2.0 ft.)
Total trench length	$=\frac{2070}{2}$ =1035 ft.

Dosing tank, alternating siphons, and twin fields required.

$\frac{1035}{2}$ =518 lineal ft. trench per field.

Maximum trench length 100 ft.; desired length 50–60 ft.
75 ft. lengths can best be worked into available disposal area with room for future additions if needed.

$\frac{518}{75}$ =7 lines of (4″) laterals required for each field.

Preferred dosing-tank capacity=75 percent of interior capacity of tile to be dosed at one time.
4″ tile=3.14×2²×12=151 cu. in. per ft.

$\frac{151 \text{ cu. in./ft.} \times 0.75}{231 \text{ cu. in./gal.}}$ =0.49 ga/lft. required dosing-tank capacity (say 0.5)

Thus the capacity of the dosing tank should be 0.5 gal./ft.×7×75 ft.=260 gallons.

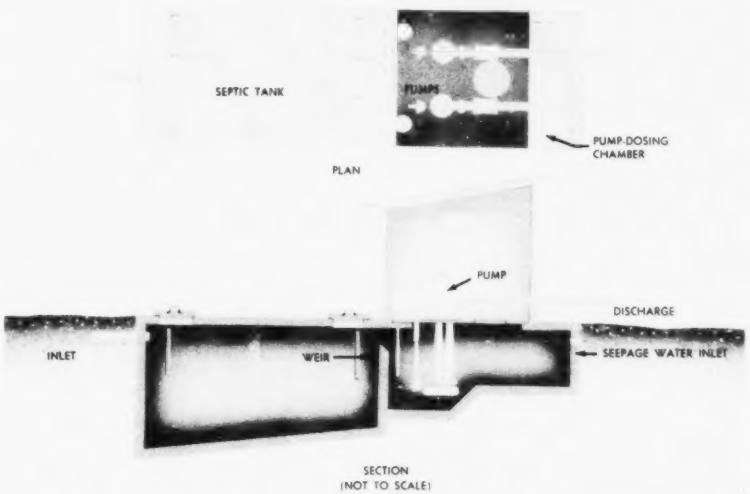

Figure 25.—Septic tank and pump-dosing chamber.

reason, filter trenches are properly regarded as a means of sewage *treatment*, and not sewage disposal. They accomplish a high degree of purification, however, and the sewage effluent coming from a filter trench that is properly designed can sometimes be disposed of without further treatment, by discharging into ditches, small streams, or dry streambeds. If the receiving stream contributes to a source of water supply, shellfish-growing area, or recreational area, chlorination should be required as hereinafter explained. In some jurisdictions, chlorination is required for all effluents from sand filters.

Nuisances are likely to be created where there are large institutions or a number of homes discharging effluents into a single ditch. In such cases, it may be advisable to lay sewers or covered drains in the ditch.

Approval should be obtained from the State or local health department before filter trenches are installed. This method of sewage treatment becomes less economical and less desirable as the quantity of sewage and the required area increase. Subsurface sand filters may be needed for larger installations.

Construction Features

Typical details of an underdrained sand-filter trench are shown in Figure 26 (page 55). For all-year service, filter trenches should be designed for filtration rates as given in Table 13.

Table 13.—*Loading rates for subsurface filters*

Type of service	Area requirements		
	Square feet per bedroom	Gallons per acre per day	Gallons per square feet per day
Without garbage-grinder or automatic washer	150	50, 000	1. 15
With garbage-grinder	180	41, 500	0. 95
With automatic washing machine	200	50, 000	1. 15
With both garbage-grinder and automatic washer	240	41, 500	0. 95

The filtering material should be clean, coarse sand, all passing a screen having four meshes to the inch. The sand preferably should have an effective size between 0.4 and 0.6 mm and a uniformity coefficient not greater than 4.0.[1] Since it is frequently difficult to obtain sand of this large size, an effective size as small as 0.25 mm may be ac-

[1] The *effective* size of a sand is that size of which 10 percent by weight is smaller. *Uniformity coefficient* is the ratio of that size of which 60 percent is smaller to the effective size.

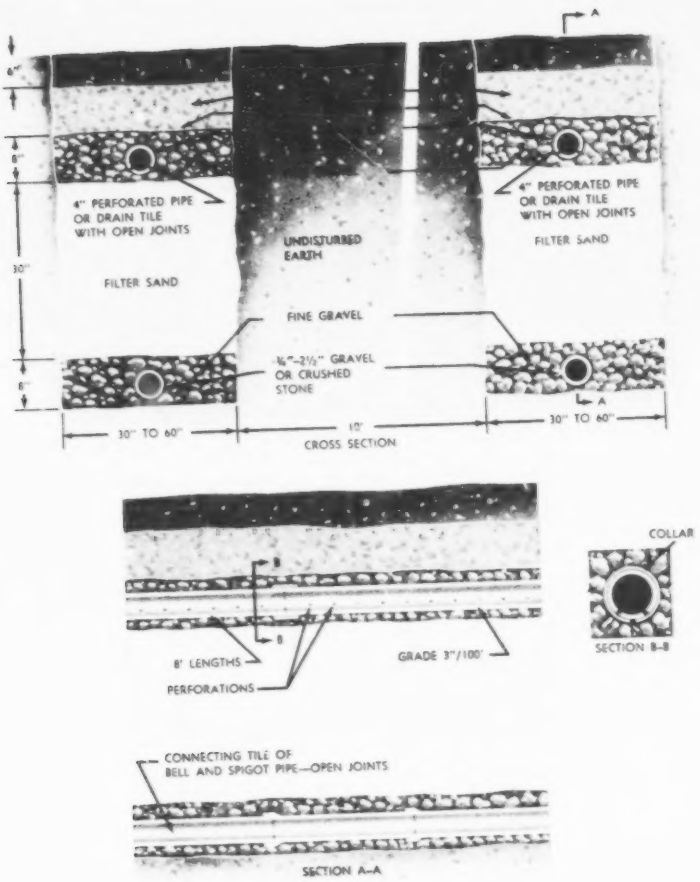

Figure 26.—Underdrained sand-filter trench.

ceptable. The coarser sands will last much longer. Fine sand will lead to premature clogging and a need for replacement. The sand should be not less than 2 feet deep.

Tile distributors, above and below the sand, should be surrounded by coarse-screened gravel or crushed stone. All of the gravel or stone should pass a 2½-inch screen and should be retained on a ¾-inch screen. Fine gravel, down to ¼-inch, may be used above and around the coarse material, both at the distributors and at the underdrains.

The slope of the distributors should be about 0.5 percent where dosing tanks are not used, and the slope of the underdrains about 0.5 to 1.0

percent. It is essential that the sand be thoroughly settled by flooding or other means before the distributors are placed at the final grade. The underdrains may be of agricultural tile or bell-and-spigot pipe, whereas perforated pipe is recommended for the distributors.

Subsurface Sand Filters

As indicated previously, filter trenches are not economical for large installations. Subsurface sand filters are cheaper. They require less area, and will do the job just as well as filter trenches. They require more care in design and construction, but this is more than offset by savings in cost. As a rough guide, filter trenches are impracticable when the amount of sewage (and consequently the filter area or the length of tile distributors) is enough to require the use of dosing siphons. Subsurface sand filters are generally indicated when dosing siphons are needed in conjunction with artificial filtration.

The principles of design of subsurface sand filters are similar to the fundamentals involved in the layout of filter trenches. Both types of installations have distributors and underdrains, with filter sand between. The essential difference in the two is that filter trenches are smaller and the filter material is laid in trenches, as implied in the name. When two or more trenches are used, natural earth is permitted to remain between them. For subsurface sand filters, on the other hand, the entire filtration area is filled in artificially. A typical plan and section of a subsurface sand filter are illustrated in Figure 27 (page 57).

Construction Features

The sand in a subsurface filter should be of a quality at least equal to that specified for a filter trench, with an effective size preferably between 0.4 and 0.6 mm, and never less than 0.25 mm, and with a uniformity coefficient less than 4.0. The gravel or crushed stone should likewise be equal to the quality previously specified. The same depth of sand is used, and the required filter area is the same as given in Table 13, with one exception: Where filters are constructed solely for seasonal use and have long rest periods over the greater part of the year, they may be expected to work satisfactorily at rates as high as twice those given in Table 13, provided that the sand has an effective size no smaller than 0.4 mm.

Dosing tanks should be provided where the total filter area exceeds 1800 square feet and where the distributors exceed 300 lineal feet. The size of the dose, or the net capacity of the dosing tank, should be 60 to 75 percent of the volume of the distributors dosed at one time. When an installation has over 800 feet of distributors, best results can be obtained by constructing the filter in two or more sections, dosed separately by alternating siphons.

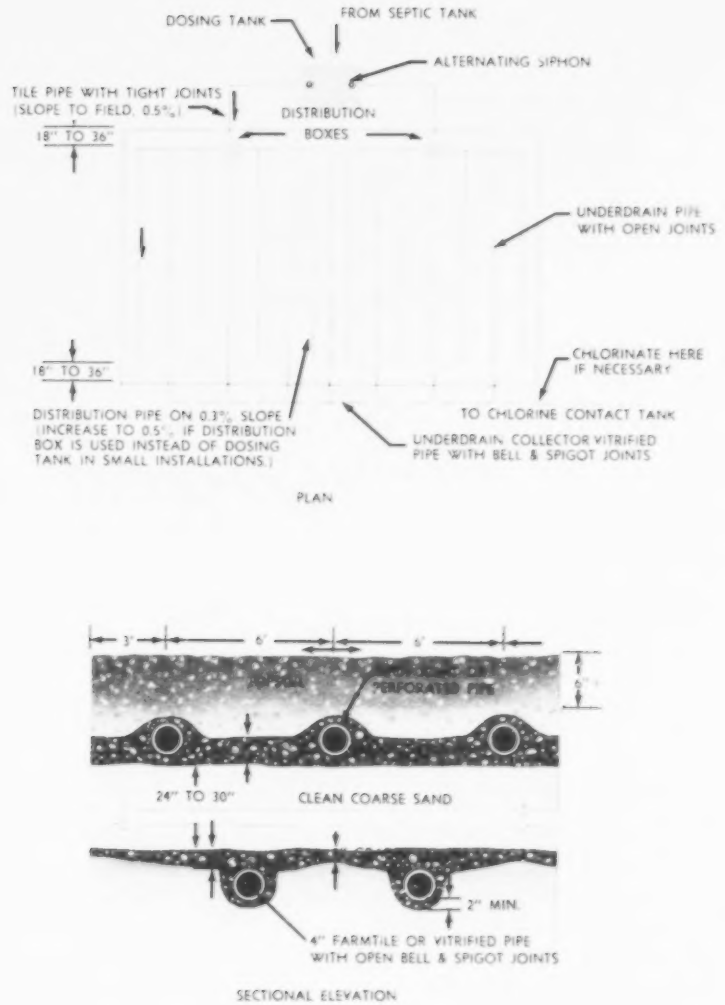
DOSING TANK
FROM SEPTIC TANK
ALTERNATING SIPHON
TILE PIPE WITH TIGHT JOINTS (SLOPE TO FIELD, 0.5%)
18" TO 36"
DISTRIBUTION BOXES
UNDERDRAIN PIPE WITH OPEN JOINTS
18" TO 36"
CHLORINATE HERE IF NECESSARY
DISTRIBUTION PIPE ON 0.3% SLOPE (INCREASE TO 0.5% IF DISTRIBUTION BOX IS USED INSTEAD OF DOSING TANK IN SMALL INSTALLATIONS.)
TO CHLORINE CONTACT TANK
UNDERDRAIN COLLECTOR VITRIFIED PIPE WITH BELL & SPIGOT JOINTS
PLAN
3'
6'
6'
PERFORATED PIPE
24" TO 30"
CLEAN COARSE SAND
2" MIN.
4" FARMTILE OR VITRIFIED PIPE WITH OPEN BELL & SPIGOT JOINTS
SECTIONAL ELEVATION

Figure 27.—Typical plan and section of a subsurface sand filter.

Underdrains may be of agricultural tile or bell-and-spigot pipe; the latter is preferred. Perforated pipe is recommended for the distributors; it comes in long lengths and has special joints that hold to better alignment than ordinary vitrified pipe with bell-and-spigot joints. If farm tile is used for distributor laterals, it should be laid on grade boards. In any event, the distributors should be laid accurately to grade *after* the filter sand has been thoroughly settled by flooding or other means.

Where dosing tanks are used, the distributors should be laid to 0.3 percent grade; otherwise, they are laid to a grade of about 0.5 percent.

SUPERFICIAL SAND FILTERS

In some areas, the ground-water table is too near the surface to permit construction or successful operation of any subsurface method of sewage disposal. The construction of buildings and sewage-disposal systems should generally be avoided in such places. Sometimes, however, the elevation of the water table may be found to fluctuate over a wide range unexpectedly. Through floods or other hydrologic conditions, areas which, for decades, may have experienced a water table appreciably below the ground surface may suddenly be faced with a condition wherein the ground water approaches or even covers the surface. Sometimes such occurrences are brought about artificially, as by the construction of dams or dikes, and the conditions may be likely to remain relatively permanent.

As previously explained, impervious soil may also preclude subsurface methods of disposal, and the occurrence of solid rock at or just below the surface of the ground may make subsurface treatment methods uneconomical.

In these events, it may be necessary to forego completely the construction or renovation of subsurface methods of sewage treatment and disposal. The circumstances may require treatment and disposal by superficial means above the surface of the ground. This frequently necessitates pumping, but can be accomplished in superficial sand filters constructed as shown in Figure 28 (page 59), except that the ends and sides must be surrounded by a masonry wall or earth dike for retaining the filter bed. The filters may be completely above the ground or only partly above the surface, depending primarily upon the depth to ground water or the depth to solid rock, as the case may be.

From the standpoint of operation, sewage filters do not have to be covered, but in built-up areas a shallow earth cover of about 6 inches is recommended, to prevent freezing in cold weather and to prevent emanation of odors and other nuisances from the septic sewage in warm weather. While open filters are accessible for cleaning and can be operated at higher rates than those covered with earth, they ordinarily require daily attention, and are not usually advisable for private installations where septic tanks are used. They are more suitable for municipalities and large institutions where sewage-plant operators are employed. In such cases, the filters generally follow a conventional primary-settling tank or secondary-treatment and secondary-settling tanks, and the method of distributing sewage onto open filters is different from that indicated for covered filters. Figure 26 (page 55) illustrates a typical installation of open filter beds.

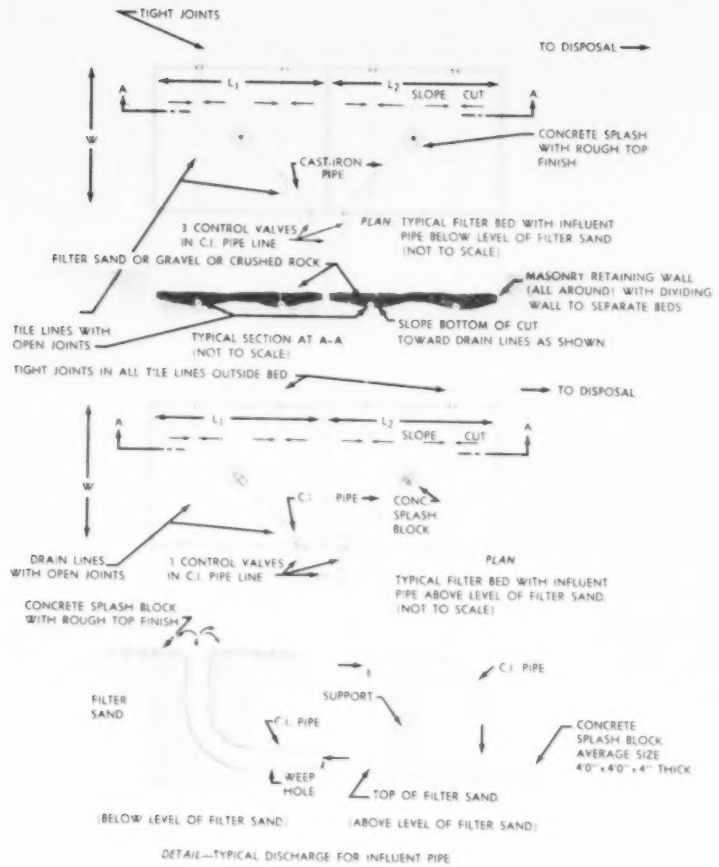
TIGHT JOINTS
TO DISPOSAL
L1
L2
SLOPE
CUT
A
W
CONCRETE SPLASH WITH ROUGH TOP FINISH
CAST-IRON PIPE
3 CONTROL VALVES IN C.I. PIPE LINE
PLAN. TYPICAL FILTER BED WITH INFLUENT PIPE BELOW LEVEL OF FILTER SAND (NOT TO SCALE)
FILTER SAND OR GRAVEL OR CRUSHED ROCK
MASONRY RETAINING WALL (ALL AROUND) WITH DIVIDING WALL TO SEPARATE BEDS
TILE LINES WITH OPEN JOINTS
TYPICAL SECTION AT A-A (NOT TO SCALE)
SLOPE BOTTOM OF CUT TOWARD DRAIN LINES AS SHOWN
TIGHT JOINTS IN ALL TILE LINES OUTSIDE BED
TO DISPOSAL
C.I. PIPE
CONC. SPLASH BLOCK
DRAIN LINES WITH OPEN JOINTS
3 CONTROL VALVES IN C.I. PIPE LINE
PLAN
TYPICAL FILTER BED WITH INFLUENT PIPE ABOVE LEVEL OF FILTER SAND (NOT TO SCALE)
CONCRETE SPLASH BLOCK WITH ROUGH TOP FINISH
C.I. PIPE
FILTER SAND
SUPPORT
C.I. PIPE
CONCRETE SPLASH BLOCK AVERAGE SIZE 4'0" x 4'0" x 4" THICK
WEEP HOLE
TOP OF FILTER SAND
(BELOW LEVEL OF FILTER SAND)
(ABOVE LEVEL OF FILTER SAND)
DETAIL—TYPICAL DISCHARGE FOR INFLUENT PIPE

Figure 28.—Open-filter-bed layout.

Open filters are operated intermittently and, thus, are known as intermittent sand filters. They should always be divided into two or more units. Sand specifications and depths are the same as for subsurface sand filters. Loading rates are influenced by temperature, effective size and uniformity coefficient of the filtering medium, and the characteristics of the sewage to be treated. The last depends largely upon the degree of pretreatment received by the influent to the filter, but, since this manual is concerned only with septic-tank systems, pretreatment may be ruled out of consideration here. Table 14 gives recommended maximum loading rates for the effluents from septic tanks which do not receive wastes from garbage grinders or automatic washing machines.

Table 14.—*Recommended loading rates of septic-tank effluents on open sand filters with uniformity coefficients not over 4.0*

[Gallons per acre per day [1]]

Region	Effective size of sand				
	0.2 mm.	0.3 mm.	0.4 mm.	0.5 mm.	0.6 mm.
Southern U. S.	100,000	130,000	160,000	180,000	200,000
Northern U. S.	80,000	100,000	120,000	140,000	160,000

[1] Multiply rates by 0.83 if garbage-grinders are used.

In addition to dosing by siphons or pumps, some open filters are dosed by means of hand-operated gates or valves. In some places, it has been customary to dose about once a day. Other plants operate with as many as 4 doses per filter per day, but some dose at long and irregular intervals of several days. With fine sands, filtration efficiencies are increased by loading twice daily. With coarse sand (0.45 mm and up), efficiencies are increased by loading more frequently than twice a day, but multiple loadings present a problem in obtaining adequate coverage of the bed. Spray nozzles and rotary distributors have been used with reasonable success as dosing devices in some small installations, but it has been found necessary to cover the surface of the sand with several inches of pea gravel in order to prevent disturbance of the surface sand.

Dosing tanks should have capacities that will provide for flooding the beds to depths of 2 to 4 inches. Discharge from the dosing tanks should at least equal the flow of the raw sewage.

Since various States have different requirements or policies regarding open filter installations, the State or local health department should always be consulted before filters of this type are designed.

CHLORINATION

Filter trenches and artificial sand filters that are properly designed and operated will produce an effluent that is clear and sparkling, and the filtration will remove a high percentage of the bacteria contained in the sewage. Some of the remaining bacteria may still be capable of producing disease, however, and the sewage effluent must be disinfected if it is discharged to a ditch that is accessible to humans, or to a stream that contributes to a nearby source of water supply used for drinking, growing of shellfish, or swimming. Chlorine is the disinfectant most commonly used.

Present custom is to apply chlorine in the amount necessary to obtain a chlorine residual of 0.5 to 1.0 ppm after thorough mixing and 15

minutes contact at peak flows. On an average, this requires a chlorine dosage in the neighborhood of 6 ppm for sand-filter effluents. This is equivalent to ½-pound of available chlorine for every 10,000 gallons of sewage, or less than 1 ounce per 1000 gallons. Most States require a chlorine contact chamber large enough to retain the sewage for at least 15 minutes. A typical design is illustrated in Figure 29 (page 62).

Chlorine may be obtained in steel cylinders in which the gas is compressed to a liquid state. It may also be obtained from sodium hypochlorite or calcium hypochlorite.

Sodium hypochlorite is obtainable only as a solution. Upon drying, it decomposes. Solutions of hypochlorite are obtainable in strengths ranging from 1 percent to 15 percent of available chlorine. This material is corrosive to ordinary metals and should be handled in stoneware crocks. Wooden barrels may be used for temporary installations.

Calcium hypochlorite is obtainable only in a dry form, of which there are two principal types. *Hypochlorite of lime* (or "bleaching powder") contains about 35 percent of available chlorine when manufactured, and *high-test hypochlorite* contains about 70 percent of available chlorine.

The ordinary hypochlorite of lime is really a mixture of compounds which may be largely a calcium oxychloride. It is not stable, and may lose a large percentage of its chlorine content if stored for long periods. When made into a water solution, it also has the undesirable characteristic of forming a scale of calcium carbonate which tends to clog the feeding apparatus. It is cheaper than high-test hypochlorite, however, and it can be used satisfactorily with certain types of feeding equipment, if large solution tanks are employed and if proper precautions are taken in the preparation and utilization of the solution. The undissolved portion must be allowed to settle out of the solution, and only the clear, supernatant liquid fed through the feeding apparatus.

High-test hypochlorite is a true calcium hypochlorite. It is more stable and more convenient to handle than ordinary hypochlorite of lime. It is available under several trade names, familiar to sanitary engineers and sanitarians. When made up with soft water in solutions containing 1 to 2 percent of available chlorine, calcium hypochlorite does not give much trouble with calcium-carbonate deposits, but precaution should still be taken to feed only the clear, supernatant portion of the solution through the feeding equipment. When hard water is used to make up the solution, the addition of a small quantity of sodium hexametaphosphate will help prevent deposits.

The decision between sodium hypochlorite or calcium hypochlorite should depend upon the relative costs of the two materials in the locality of the job. Information as to their costs can usually be obtained from the suppliers of the hypochlorinators.

The decision as to whether to apply chlorine as a gas or in liquid form as a hypochlorite is some times dependent on the availability of

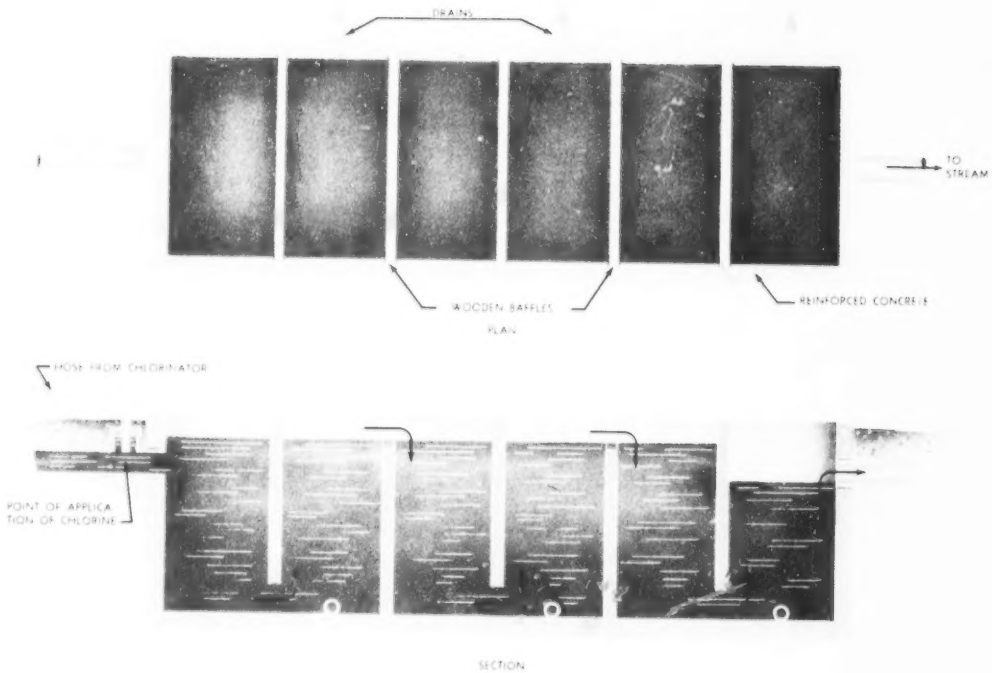

Figure 29.—Chlorine-contact chamber.

power. Most manufactured hypochlorinators require either electric current or clean water under pressure for their operation. In some remote places, these are not available. In such cases, chlorinators using chlorine in cylinders can be operated without any outside power source.

Usually, however, power is available and the decision as to whether to use hypochlorite or chlorine gas is dependent upon their relative cost. Gas is the cheaper of the two, but equipment for controlling it is much more expensive than simple hypochlorite feeders.

In general, hypochlorite is preferred when the amount of chlorine required is less than 2 or 3 pounds per day. In other words, hypochlorite would normally be used for disinfecting the effluent from a sand sewage filter for sewage flows up to about 50,000 gallons per day. For chlorinating a septic-tank effluent, the sewage-flow limit for hypochlorinators would be about 10,000 gallons per day. Beyond these quantities, savings in the cost of the chlorine gas will usually offset the more-expensive original investment in equipment.

Several satisfactory types of hypochlorinators are available. Various types of chlorinators are also made. Both kinds of apparatus are being gradually improved. Both require occasional maintenance. Therefore, in choosing the make of apparatus to be purchased, the first consideration should be that of service. It is practically always advisable to purchase a chlorinator from a manufacturer who has a full-time serviceman traveling through the area where it is to be used. Jobbers and agents handling chlorinators are seldom qualified to furnish the best technical assistance, and are usually unable to render the prompt service that is necessary when a chlorinator gets out of order.

Wherever chlorination is necessary, daily tests should be made to determine the amount of chlorine residual after the requisite contact period. Many health departments require monthly reports giving the results of the tests.

The test is simple. It is usually made by adding a small amount of standard orthotolidine solution to a sample of the effluent and comparing the color developed with color standards which may be obtained with the solution from most laboratory supply houses. If the color of the sample changes to an orange-yellow hue, it indicates that chlorine is being applied in a proper amount.

Appendices

Introduction to Appendices

Since conditions vary in different parts of the country, practices that are suitable in one section may not be acceptable in another. Thus, it would not be feasible to suggest one set of standards that should be followed in all circumstances. In a sense, this may be considered fortunate, as, to paraphrase Sedgwick, "Standards are devices to keep the lazy mind from thinking." In public-health work there can be no substitute for the use of judgment or discretion, more aptly termed by Phelps as an exercise of "the principle of expediency."

Just as no individual design of a sewage-disposal system is applicable for universal adoption because of varying local conditions, so also no single ordinance or code would be universally applicable. Though some States and many local health departments have laws or regulations governing the installation of individual sewage disposal systems, there is still a growing need for reasonable regulations which will protect the public from unsound practices leading to health hazards. The suggested ordinance governing individual sewage-disposal systems presented in these appendices may be useful as a guide in the development of new, or the revision of existing, regulations on this subject.

The purpose of these appendices, therefore, is to discuss additional practices which have been found successful in some parts of the country, although their application may be necessarily limited in other parts, and also to present some additional information considered useful to workers in this field.

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Appendix A

Soil Absorption Capacity

GUIDE FOR ESTIMATING SOIL-ABSORPTION POTENTIAL

A percolation test is the only known means for obtaining a quantitative appraisal of soil-absorption capacity. However, there are other means by which a rough appraisal of this potentiality can be made. A general idea of the relative capacity of a soil to absorb fluid can be obtained from certain clues to soil characteristics. It must be recognized, however, that this procedure provides merely the opportunity for dividing soils into three or four very broad categories. To obtain specific values it is necessary to make absorption tests, as described earlier in this manual.

Thus, deep sands and loessial soils of considerable depth can be segregated from clays and clay loams, with the advantage that the sands and deep loessial silt loams, in all likelihood, will give little trouble in the design of septic-tank systems. It is at the other end of the spectrum of soil permeability (i. e., clays and clay loams) that problems will commonly arise, and it is in this range that careful measurements of absorption capacity are especially needed. Clues are useful in broadly identifying problem soils, but they cannot indicate precise absorption rates.

Soil Maps.—The capacity of a soil to absorb and transmit water is an important problem in agriculture, particularly in relation to irrigation, drainage, and other land-management practices. Through studies in these fields, a variety of aids have been developed for judging the absorption of water-transmission properties of soils, which could be helpful in the sewage field. Considerable information has been accumulated by agricultural authorities on the relative absorption capacities of specific soils in many areas of the United States. Much of this information is included in Soil Survey Reports and Maps published by the United States Department of Agriculture in cooperation with the various State agricultural colleges. The general suitability of specific soils for effluent disposal may often be interpreted from these reports and maps.

Clues to Absorption Capacity.—Considerable information about relative absorption capacities of soils may also be obtained by a close visual inspection of the soil. The value of such an inspection depends upon some knowledge of the pertinent soil properties. The main properties indicative of absorption capacity are soil texture, structure, color, depth or thickness of permeable strata, and swelling characteristics.

Texture.—Soil texture, the relative proportion of sand, silt, and clay, is the most common clue to water-absorption capacity. The size and distribution of particles govern the size and distribution of pores which, in turn, govern the absorption capacity. The larger the soil particles, the larger are the pores and the faster is the rate of absorption.

Texture can best be judged by the feel. The lighter or sandier soils have a gritty feel when rubbed between the thumb and forefinger; silty-type

soils have a "floury" feel and, when wetted, have no cohesion; heavier, clay-type soils are dense and hard when dry, and have a slick greasy feel when wetted.

The use of texture as a clue to absorption qualities has its limitations; it is primarily reliable in the sandier soils. In the heavier-type soils, including sandy soils containing appreciable amounts of silt or clay, one must look for additional clues, such as structure and soil color, as indicators of absorption capacity.

Structure.—Soil structure is characterized by the aggregation or grouping together of textural particles, forming secondary particles of larger size. Such secondary particles then tend to govern the size and distribution of pores and, in turn, the absorption properties. Structure can easily be recognized by the manner in which a clod or lump breaks apart. If a soil has structure, a clod will break with very little force, along well-defined cleavage planes, into uniformly sized and shaped units. If a soil has no structure, a clod will require more force to break apart and will do so along irregular surfaces, with no uniformity in size and shape of particles.

In general, there are four fundamental structure types, named according to the shape of the aggregate particles: Platy, prism-like, block-like, and spheroidal. A soil without structure is generally referred to as massive. Spheroidal structure tends to provide the most favorable absorption properties, and platy structure, the least. Although other factors, such as size and stability of aggregates to water, also influence the absorption capacity, recognition of the type of structure is probably sufficient for a general appraisal.

Color.—One of the most important practical clues to water absorption is soil color. Most soils contain some iron compounds. This iron, like iron in a tool or piece of machinery, if alternately exposed to air and to water, oxodizes and takes on a reddish-brown to yellow color. Thus, if a soil has uniform reddish-brown to yellow oxidized color, it indicates that there has been free alternate movement of air and water in and through the soil. Such a soil has desirable absorption characteristics. At the other extreme are soils of a dull-gray or mottled coloring, indicating lack of oxidizing conditions or very restricted movement of air and water. These soils have poor absorption characteristics.

Depth or Thickness of Permeable Strata.—The quantity of water that may be absorbed is proportional to the thickness or volume of the absorbent stratum, when all other conditions are alike. In a soil having a foot or more of permeable material above tight clay, absorption capacity is far greater than that of the same kind of material lying within 3 inches of tight clay. When examining soils or studying soil descriptions, the depth and thickness, therefore, are important criteria of absorption capacity.

Swelling Characteristics.—Most, but not all, clays swell upon the addition of moisture. There are many clays (in the tropics, in particular) that do not swell appreciably. There are also some soils in the United States which do not swell noticeably. On the other hand, some soils have a very high percentage of swelling, and these in particular must be suspect. Relative swelling of different soils is indicated by relative shrinkage when dry, as shown by the numbers and sizes of cracks that form. Those that shrink appreciably when dry are soils that may give trouble in a tile field when they are wet.

Information obtained through inspection or from soil maps and reports can be of particular value in preliminary appraisal of soils for sewage dis-

posal. For instance, in many cases, unsuitable soils may be immediately ruled out on the basis of such information; in other cases, selection of the best of several sites may be made on the basis of the inspection. Absorption-capacity information obtained in this manner is relative. For quantitative information upon which to base specific design, we still must depend on some direct measurement, such as a water-absorption rate as measured by a percolation test.

EVAPOTRANSPIRATION SYSTEMS

In tight clay soils, where leaching is very limited, plant transpiration has been employed with some degree of success for the disposal of sewage effluent. By placing the tile lines near the top of the trench, where they are not likely to become clogged with roots, or by laying the lines practically at ground surface and covering with suitable fill material, use may be made of the action of trees, shrubs, and grasses in the absorption and subsequent release to the atmosphere of appreciable quantities of moisture, through the process of evapotranspiration.

Climate is important. Evapotranspiration increases with decreasing humidity and increasing temperature and air turbulence. Length of day and amount of sunshine are further influencing factors. Consequently, evapotranspiration should be of most benefit to soil-absorption systems in the southern portion of the country, where the growing season is longest. In the extreme North, where the growing season extends only from May to September, evapotranspiration would be of minimum value, but may be useful in summer-resort areas.

Because of these variations, and equally great variations in the types of plants grown in different parts of the country, as well as the differing transpiration rates in different plants, it would be hazardous to generalize in making specific suggestions on design criteria for systems dependent on evapotranspiration for successful operation. Their proper design in any area suggests the need for competent enginering, together with a considerable knowledge of soil science and agriculture. However, the amount of evapotranspiration should not generally be expected to exceed 0.2 gallon per square foot per day in absorption fields that are covered solidly with grass.

USE OF POLYELECTROLYTES

Synthetic polyelectrolytes have been used to improve the filterability of the tight soils, and there has been much speculation concerning their use in subsurface sewage-disposal systems. Studies have demonstrated that the use of polyelectrolytes will greatly increase the permeability of clay soils for short periods of time, but that the cost of such treatment for disposal areas would be prohibitive in most cases. At prices prevailing in 1954, the cost of polyelectrolyte alone would increase the cost of an ordinary trench by $3.50 per foot under the conditions studied. Furthermore, it was found that the effective life of the material, measured by the length of time a high percolation rate was sustained, was only a few weeks or months in a sewage-absorption system. This compares with an effective life of two or three years as reported for the usefulness of single applications for agricultural purposes.

CURTAIN DRAINS FOR ABSORPTION TRENCH SYSTEMS

Even though proper precautions are taken to ascertain the maximum ground-water table before the absorption-trench method of sewage-effluent disposal is approved for a given area, instances occur where the height of a water table rises above that indicated by past performances and observations. This may lead to failure of the disposal system.

It is sometimes possible to rehabilitate such a system by constructing around the disposal area a curtain drain designed to intercept the superficial ground water and carry it away from the area. If the absorption field is on sloping ground, a single drain at the upper end of the area may be sufficient. Where open curtain drains are not feasible, rock-filled trenches above or around the disposal area may sometimes be used. In either case, it is necessary to have a suitable outlet for the ground water that is intercepted.

PERCOLATION TEST HOLES

When making percolation tests in some types of soil, it has been found that the side walls of test holes have a tendency to cave in or slough off, and settle to the bottom. The condition is most likely to occur where the earth is initially dry and overnight soaking is necessary. The caving can be prevented, and more accurate results obtained, by placing in the test hole a wire cylinder surrounded by gravel of the same size that is used in the tile field.

AUTOMATIC TIMERS FOR PERCOLATION TESTS

A patented "percolation timer" which will record on a clock the time it takes water to dissipate from a soil-percolation test hole was placed on the market in 1953. It consists of a base plate that will rest over any-sized percolation hole up to 12 inches, and legs that will adjust the base to a horizontal position. On the plate is a clock equipped with an automatic trip mechanism that stops the clock after a float in the test hole drops a predetermined distance, usually 6 inches. Presoaking the test holes 12 hours before the tests is considered a part of the routine preparation.

OTHER PERCOLATION TESTS

A Soil Percolation Test for Determining the Capacity of Soils for Leaching Sewage Effluents, by John E. Kiker, Jr.[1]

1. Dig a hole about 1 foot square to the depth at which it is proposed to lay the tile drain.
2. Fill the hole with water and allow the water to seep away. When the water level falls to within 6 or 8 inches of the bottom of the hole, observe the rate at which the water level drops.
3. Continue these observations until the soil is saturated and the water seeps away at a *constant rate*. (Keep adding water until the rate becomes constant.)

[1] Reprinted from Subsurface Sewage Disposal, by John E. Kiker, Jr., Bulletin No. 23, Florida Engineering and Industrial Experiment Station, 1948.

4. Compute the time required for the water to drop 1 inch after the soil becomes saturated. This is the standard percolation time, t.

A Percolation Test for Determining the Capacity of Soils for Leaching Sewage Effluents, by Harvey F. Ludwig, Gordon W. Ludwig, and John Stewart.

While the previously cited percolation tests include procedures generally familiar to workers in this field, the method proposed by Ludwig et al., includes an additional step: The field data are further analyzed graphically to obtain the percolation rate under saturated-soil conditions. The mathematical evaluation is based on the premise that the ratio, time in minutes for the water level to drop 1 inch, is constantly increasing during the progress of the test, but at a rate of increase which is constantly decreasing. This hyperbolic relationship is utilized to determine the maximum ratio—$\frac{\text{minutes}}{\text{inch}}$—which is the saturated condiiton under which water would seep away at a constant rate. A discussion of this method with illustrations and an example is found in the following articles, Improved Soil Percolation Test, Harvey F. Ludwig and Gordon W. Ludwig, *Water and Sewage Works Journal*, vol. 96, no. 5, May 1949, p. 192; Equilibrium Percolation Test for Estimating Soil Leaching Capacity, Harvey F. Ludwig and John Stewart, *Modern Sanitation*, vol. 4, no. 10, Oct. 1952.

Appendix B

Alternate Design for Deep-Wide Trenches

While there is no scientific evidence as to the amount of additional capacity provided by deep-wide trenches, a purely rational consideration of the criteria governing the design of standard, narrow trenches indicates the need for modification of design factors for trenches deeper and wider than those commonly used. This statement is predicated on the following factors:

1. Increase in width of trench beyond 36 inches does provide additional absorption area. The additional area becomes effective when needed, that is, when the area in the immediate vicinity of the distributing tile is momentarily overtaxed. The same distribution problem and phenomena exist in standard trenches.

2. The vertical side-wall area of the trench does constitute additional absorption area during periods of intermittent ponding which may occur at maximum loadings. During the periods of such ponding, the vertical sides of the trench permit leaching into the subsoil in much the same manner as a seepage pit.

The following is a tentative, rational design procedure suggested for such cases, pending the conclusion of present studies[2] that may provide definite design criteria, which recognizes the increased absorption area provided in wide or deep trenches where there is a reasonable basis to assume that percolation is a function of both vertical and horizontal areas. (The examples below assume that the soil strata are uniform throughout the depth of the trench.)

1. The absorption area of the trench is the total area, both horizontal and vertical, beneath the tile line.

2. The system shall be designed on the basis of the criteria shown in Table 15 (see page 72).

The primary advantage of the deep-wide trench system over the conventional trench system is the resultant reduction in lengths of trench required in a given system. It should be recognized that this alternate design procedure is applicable to trenches over 4 feet in width and having 12 inches or more of gravel below the tile. The following examples illustrate these points. Conventional design calculations are included for purposes of comparison.

[2] Underway at Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

Table 15.—Design criteria for deep-wide trench systems

PERCOLATION RATE (Min. per in.)	Column I RESIDENTIAL Sq. Ft. per Bedroom [1, 2]	Column II INSTITUTIONAL Gal./sq. ft./day [1, 3]
1 or less	140	2.5
2	170	1.8
3	200	1.5
4	230	1.3
5	250	1.1
10	330	0.8
15	380	0.7
30 [4]	500	0.5

[1] Absorption area is figured as bottom area and effective side-wall area below the tile.

[2] Provides for garbage-grinder and automatic-sequence washing machine.

[3] Not including effluents from septic tanks that receive wastes from garbage-grinders and automatic washing machines. Add 20 percent to calculated area for garbage-grinder; 40 percent for automatic washers; 60 percent if both are used.

[4] Over 30 unsuitable for leaching systems designed by this alternate method.

Residential

Example I. Assume: Percolation rate, 1 inch in 5 minutes. Trench width, 2 feet.

	Conventional design	*Alternate design*
Depth of gravel	6 in.	24 in.
Area needed per bedroom	125 sq. ft.	250 sq. ft.
Area available per linear foot	2 sq. ft.	6 sq. ft.
Length of trench required per bedroom	$\frac{125}{2}$ = 62.5 ft.	$\frac{250}{6}$ = 41.7 ft.

Example II. Assume: Percolation rate, 1 inch in 5 minutes. Trench width, 4 feet.

	Conventional design	*Alternate design*
Depth of gravel	6 in.	36 in.
Area needed per bedroom	125 sq. ft.	250 sq. ft.
Area available per linear foot	3 sq. ft.	10 sq. ft.
Length of trench required per bedroom	$\frac{125}{3}$ = 41.7 ft.	$\frac{250}{10}$ = 25 ft.

Institutional

For each example assume: 5,000 gallons of sewage per day to be disposed of; percolation rate, 1 inch in 5 minutes.

Example I.	*Conventional design* (Table 1, p. 6)	*Alternate design* (Table 15, p. 72)
Width of trench	2 ft	2 ft.
Depth of gravel	6 in	24 in.
Absorption area required	5000 gal/day ÷ 2.2 gal/sq ft/day = 2270 sq ft absorption area required	5000 gal/day ÷ 1.1 gal/sq ft/day = 4546 sq ft absorption area required
Length of trench required	2270 sq ft ÷ 2 sq ft/ft = 1135 linear ft of trench required	4546 sq ft ÷ 6 sq ft/ft = 758 linear feet of trench required

Example II.	*Conventional design*	*Alternate design*
Width of trench	4 ft	4 ft.
Depth of gravel	6 in	36 in.
Absorption area required	2270 sq. ft	4546 sq. ft.
Length of trench required	2270 sq ft÷3 sq ft/ft=757 linear ft of trench required	4546 sq ft÷10 sq ft/ft=455 linear ft of trench required

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Appendix C

Suggested Ordinance

The following is suggested for consideration in drafting an ordinance for local application to permit the exercise of apropriate legal controls over individual sewage-disposal systems. Persons utilizing this draft as a guide are urged to familiarize themselves with the applicable legal requirements governing adoption of ordinances of this kind in their locality.

AN ORDINANCE GOVERNING INDIVIDUAL SEWAGE DISPOSAL SYSTEMS

An ordinance defining and regulating individual sewage-disposal systems; requiring minimum standards governing the design, construction, and installation of septic-tank soil-absorption systems, privies, and chemical-type toilets; authorizing the issuance of permits, and providing for penalties for violations.

Section I—Definitions

1.1 For the purposes of this ordinance, the following words and phrases shall have the meanings ascribed to them in this section.

1.1.1 *Health officer* shall mean the legally designated health authority of the (name of political subdivision) or his authorized representative.

1.1.2 *Individual sewage-disposal system* shall mean a sewage-disposal system, other than a public or community system, which receives either human excreta or liquid waste, or both, from one or more premises. Included within the scope of this definition are septic-tank soil-absorption systems, privies, and chemical-type toilets, and such other types as may be prescribed in regulations by the health officer.

1.1.3 *Permit* shall mean a written permit issued by the health officer, permitting the construction of an individual sewage-disposal system under this ordinance.

1.1.4 *Person* shall mean any institution, public or private corporation, individual, partnership, or other entity.

Section II—Requirements for Individual Sewage-Disposal Systems

2.1 The health officer of (name of political subdivision), in order to protect the health and safety of the people of (name of political subdivision) and of the general public, is authorized and directed, after public hearing, to promulgate and amend, from time to time, regulations establishing mini-

mum standards governing the design, construction, installation, and operation of individual sewage-disposal systems. Such regulations shall establish such minimum standards as, in the judgment of the health officer, will insure that the waste discharged to various individual sewage disposal systems:

1. Do not contaminate any drinking-water supply.
2. Are not accessible to insects, rodents, or other possible carriers of disease which may come into contact with food or drinking water.
3. Do not pollute or contaminate the waters of any bathing beach, shellfish breeding grounds,[4] or stream used for public or domestic water-supply purposes or for recreational purposes.
4. Are not a health hazard by being accessible to children.
5. Do not give rise to a nuisance due to odor or unsightly appearance.
6. Will not violate any other laws or regulations governing water pollution or sewage disposal.

2.2 The health officer is authorized to promulgate such additional regulations as are necessary in his judgment to carry out the provisions of this ordinance.

Section III—Permits

3.1 It shall be unlawful for any person to construct, alter, or extend individual sewage-disposal systems within the (name of political subdivision) unless he holds a valid permit [5] issued by the health officer in the name of such person for the specific construction, alteration, or extension proposed.

3.2 All applications for permits shall be made to the health officer, who shall issue a permit upon compliance by the applicant with provisions of this ordinance and any regulations adopted hereunder.

3.3 The health officer may refuse to grant a permit for the construction of an individual-sewage-disposal system where public or community sewerage systems are reasonably available.

3.4 Applications for permits shall be in writing, shall be signed by the applicant, and shall include the following:

3.4.1 Name and address of the applicant.
Lot and block number of property on which construction, alteration, or extension is proposed.

3.4.3 Complete plan of the proposed disposal facility, with substantiating data, if necessary, attesting to its compliance with the minimum standards of the health officer.

3.4.4 Such further information as may be required by the health officer to substantiate that the proposed construction, alteration, or extension complies with regulations promulgated by the health officer.

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[4] Optional with locality.

[5] The permit issued by the Health Officer is in addition to the building permit usually required and should be obtained prior to construction, alteration, and extension of the residence or facility to be served.

3.5 A complete plan for the purpose of obtaining a permit to be issued by the health officer shall include:

3.5.1 The number, location, and size of all sewage-disposal facilities to be constructed, altered, or extended.

3.5.2 The location of water supplies, water-supply piping, existing sewage-disposal facilities, buildings or dwellings, and adjacent lot lines.

3.5.3 Plans of the proposed sewage disposal facilities to be constructed, altered, or extended.

3.6 Any person whose application for a permit under this ordinance has been denied may request and shall be granted a hearing on the matter before the health officer within 30 days after receipt of the request.

Section IV—Inspections

4.1 The health officer is hereby authorized and directed to make such inspections as are necessary to determine satisfactory compliance with this ordinance and regulations promulgated hereunder.

4.2 It shall be the duty of the owner or occupant of a property to give the health officer free access to the property at reasonable times for the purpose of making such inspections as are necessary to determine compliance with the requirements of this ordinance and regulations promulgated hereunder.

Section V—Penalties

5.1 Any person who violates any provision of this ordinance, or any provision of any regulation adopted by the health officer pursuant to authority granted by this ordinance, shall, upon conviction, be punished by a fine of not less than _____ dollars nor more than _____ dollars, or by imprisonment for not less than _____ days nor more than _____ days; and each day's failure to comply shall constitute a separate violation.

Section VI—Conflict of Ordinances, Effect on Partial Invalidity

6.1 In any case where a provision of this ordinance is found to be in conflict with a provision of any zoning, building, fire, safety, or health ordinance or code of this (name of poiltical subdivision) existing on the effective date of this ordinance, the provision which, in the judgment of the health officer, establishes the higher standard for the promotion and protection of the health and safety of the people shall prevail. In any case where a provision of this ordinance is found to be in conflict with a provision of any other ordinance or code of the (name of political subdivision) existing on the effective date of this ordinance which establishes a lower standard for the promotion and protection of the health and safety of the people, the provisions of this ordinance shall be deemed to prevail, and such other ordinance or codes are hereby declared to be repealed to the extent that they may be found in conflict with this ordinance.

6.2 If any section, subsection, paragraphs, sentence, clause, or phrase of this ordinance should be declared invalid for any reason whatsoever, such decision shall not affect the remaining portions of this ordinance, which shall remain in full force and effect; and, to this end, the provisions of this ordinance are hereby declared to be severable.

Section VII—Effective Date

7.1 This ordinance shall be effective on and after the _____ day of _____, 19__.

Appendix D

Engineering Information Forms

The pertinent information needed on individual sewage-disposal systems prior to approval by the health or other agency having jurisdiction is outlined in Appendix C. In those instances where subdivision developments are involved, considerably more data are needed by the health agency prior to approval of water- and sewage-service facilities. The possibility of providing connections to existing municipal systems or the construction of community water and sewage systems should receive first consideration. In the extreme situation where this is not possible, and when subsoil conditions are favorable, information of the type called for in the following "Statement of Information" has been found satisfactory in one State. Unless real-estate developments in nonsewered areas are properly planned and designed under competent sanitary engineering supervision, public-health hazards and nuisances may result, with attendant economic loss to the community.

STATE DEPARTMENT OF HEALTH

STATEMENT OF INFORMATION

REGARDING WATER AND SEWERAGE SERVICE FOR REALTY SUBDIVISIONS

To the State Commissioner Health _____ 19 _____

SIR:

As required by the provisions of section _____ of Article ____ of the Public Health Law, the following statement is made and submitted with the plat of a proposed realty subdivision in _____
(State)

General Information

1 Name of subdivision _____

2 Owner _____
(State name of person, company, corporation, or association, owning the subdivision)

3 Business address _____

4 Officers _____
(If organized, give names of officers)

5 Location _____
(Give name of incorporated village or town in which subdivision is located)

6 Area of subdivision _____ Number of lots _____ Families accommodated _____
(Total size in acres)

7 Do you intend to build houses on this subdivision ? _____
Do you intend to sell lots only? _____

Do you intend to build on some lots and sell others without buildings? _____

8 Is this subdivision or any part thereof located in an area under the control of local planning, zoning, or other officials? _____
If so, have these plans been submitted to such authorities? _____
Have these plans been approved or disapproved by such governing authority? _____

9 Nature of soil _____
(Describe to a depth of 10 feet if tile fields are to be used _____
for sewage disposal, or 20 feet if leaching pits are proposed, giving thickness _____
of various strata, such as top soil, clay, loam, sand, gravel, rock, etc.)

10 Topography _____
(State whether ground is flat, rolling, steep, or gentle slope, etc.)

11 Relative elevation of water table below ground surface _____
(Give maximum _____
and minimum, if there is any variation)

Water Service

12 Proposed method of supplying water _____
(Describe in detail, giving name _____
of municipality, water district or company, if a public water supply is to be used.)

13 State approximate *distance* to nearest public water-supply main of municipal system _____
_____
(Give name of municipality, water district, or company)

Sewerage Service

14 Proposed method of collection and disposal of sewage _____
_____
(Give name of municipality or sewer district, if public sewers are to be used)

15 State approximate *distance* to nearest public sewer main of municipal system _____

Storm-Water Drainage

16 State proposed method, if any, of disposing of surface water from streets, roofs, land, and other areas _____
_____

Subdivision Owners Who Intend To Build Homes Must Submit the Following Additional Information:

Additional Information:

17 Cellar drainage: Are cellar or footing drains to be installed? _____
If so, how will drainage be disposed of? _____

18 Laundry wastes: Are laundry tubs to be located in basement? _____
If so, how will wastes be disposed of? _____
It is hereby agreed that if the attached plans dated _____,
or any amendment or revision thereof, are approved by the State De-

partment of Health, installation of water-supply and sewage-disposal facilities will be made in accordance with the details thereof as shown on such approved plans. If the subdivided lands shown on such plans are sold before such installations are made, it is agreed that reference to said plans will be made in the deed or contract of sale, and a covenant inserted therein requiring the purchaser to install such facilities in accordance with such approved plans.

Signature _____

Official title _____

This statement must be signed by the owner of the land platted for subdivision or the responsible official of the company or corporation offering the same for sale.

Important Note

This form must be accompanied by:

(1) One U. S. G. S. topographic map or other general map showing exact location and approximate boundaries of subdivision.

(2) A print on cloth for filing with the State Department of Health, together with such other tracings and prints (see below) as may be necessary for filing with the county clerk and owner of the subdivision, showing:

(a) subdivision layout, including streets, building lines, lot dimensions, and other pertinent data;

(b) existing and proposed water mains, if available. If public water supply is available, show existing and proposed water mains for all lots, and submit a copy of the contract between the developer and the waterworks officials, or a letter from such officials stating that an agreement has been reached regarding the supply of such facilities.

(c) existing and proposed sewers; if already approved by Department give date of approval; or, if not approved, application must be made and detailed plans of sewer extensions submitted by officials in charge of sewer systems, in accordance with section _____ of the Public Health Law.

(d) details of a typical lot arrangement showing general location of well and septic tank, subsurface absorption devices, etc. (where either or both public water and sewerage service are inaccessible), plus the following:

(1) development of well (giving sufficient detail to show how the well will be developed and protected from pollution, its depth, and strata penetrated).

(2) cross section of soil showing depth of various strata (unless explained in detail under item 9).

(3) plan and section of all parts of sewage-disposal system, giving all dimensions and grades.

(4) actual field results of soil tests to determine absorptive capacity of soil (may be submitted with correspondence).

Inasmuch as stamp of approval must be placed on face of plans, a space 3 by 6 inches should be reserved for this purpose. This space must be blocked out in white if blueprints are submitted.

Size of plans for filing with county clerk: 20 by 20 inches or 20 by 40 inches—tracing cloth or white prints on cloth.

Appendix E

Fixture Unit Values[6]

Fixture type	*Fixture unit value as load factor*
1 bathroom group:	
With tank water closet	6
With flush valve closet	8
Bathtub (with or without overhead shower)	2
Bidet	3
Combination sink-and-tray	3
Combination sink-and-tray with food disposal unit	4
Dental unit or cuspidor	1
Dental lavatory	1
Drinking fountain	½
Dishwasher (domestic)	2
Floor drains	1
Kitchen sink (domestic)	2
Kitchen sink (domestic, with food-waste grinder)	3
Lavatory with small pullout plug	1
Lavatory with large pullout plug	2
Lavatory (barber, beauty parlor)	2
Lavatory (surgeon's)	2
Laundry tray (1 or 2 compartments)	2
Shower stall (domestic)	2
Showers (group) (per head)	3
Sinks:	
Surgeon's	3
Flushing rim (with valve)	8
Service (trap standard)	3
Service (P trap)	2
Pot, scullery, etc	4
Urinal (pedestal) (siphon jet, blowout)	8
Urinal (wall lip)	4
Urinal (stall, washout)	4
Wash sink (circular or multiple) (each set of faucets)	2
Water closet (tank-operated)	4
Water closet (valve-operated)	8

Fixtures not listed above may be estimated as follows:

Fixture drain or trap size	*Fixture unit value*
1¼ inches and smaller	1
1½ inches	2
2 inches	3
2½ inches	4
3 inches	5
4 inches	6

For continuous or semicontinuous flow into a drainage system, such as from a pump, pump ejector, air-conditioning equipment, or similar device, two fixture units should be allowed for each gallon-per-minute of flow.

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[6] Extracted from American Standard National Plumbing Code (ASA A40.8-1955) with the permission of the publisher, The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.

Appendix F

Suggested Specifications for Watertight Concrete

1. Materials

Portland cement should be free of hard lumps caused by moisture during storage. Lumps from dry packing that are easily broken in the hand are not objectionable.

Aggregates, such as sand and gravel, should be obtained from sources known to make good concrete. They should be clean and hard. Particle size of sand should range very fine to ¼-inch. Gravel or crushed stone should have particles from ¼-inch to a maximum of 1½ inches in size.

Water for mixing should be clean.

2. Proportioning

Not more than 6 gallons of total water should be used for each bag of cement. Since sand usually holds a considerable amount of water, not more than 5 gallons of water per bag of cement should be added at the mixer when sand is of average dampness. More mixing water weakens the concrete and makes it less watertight. For average aggregates, the mix proportions shown in Table 16 will give watertight concrete.

Table 16.—*Average proportions for watertight concrete*

Max. Size Gravel (in.)	Cement (volume)	Water [1] (volume)	Sand (volume)	Gravel (volume)
1½	1	¾	2¼	3
¾	1	¾	2½	2½

3. Mixing and Placing

All materials should be mixed long enough so that the concrete has a uniform color. As concrete is deposited in the forms, it should be tamped and spaded to obtain a dense wall. The entire tank should be cast in one continuous operation, if possible, to prevent construction joints.

4. Curing

After it has set, new concrete should be kept wet for several days to gain strength. A good method of curing is to leave the forms in place for about 5 days.

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[1] Assuming sand is of average dampness.

Appendix G

Industrial Waste Treatment

Septic-tank systems are not employed for the treatment of industrial wastes from large manufacturing industries. In small industrial plants, septic-tank systems, assisted as needed by supplementary processes may be used advantageously either for treating wastes to render them suitable for final disposal by one of the methods described in Part II, or for conditioning wastes to render them acceptable for discharge to sewer systems where they would otherwise be objectionable.

It is important to note that the design of septic-tank systems for treatment and disposal of industrial wastes is not sufficiently simple to permit formulation of specific criteria for design. This is because industrial wastes vary widely in their composition; in fact, rarely do any two plants produce wastes of the same character and composition. The design of an industrial-waste treatment and disposal system is, therefore, a problem requiring specialized sanitary engineering consultation, and this consultation usually includes special laboratory analyses and studies of the particular wastes under consideration. With these precautions, however, it is possible, in many instances, to develop a workable septic-tank system which is actually simple, effective, economical, and within the means of the small industrial plant.

The following is intended to indicate only qualitatively some of the methods applicable to a few industrial wastes. The particular design for any given waste must be prepared by competent sanitary engineers.

LAUNDRY WASTES AND OTHER GREASY WASTES

Wastes derived from laundries and some other sources, which contain soaps, oil, and greases in relatively low concentrations, may be successfully disposed of by one of the methods previously described, provided the greasy substances are first removed. If greasy substances, including soaps and oils, are discharged into leaching systems, they accumulate and soon cause clogging of the soil pores.

The greasy substances contained in wastes are of two types: (1) the floatable greases, which are nonemulsified and which, therefore, upon quiescence or standing, will separate and rise to the surface of the liquid to form a surface layer; and (2) the emulsified greases, which do not separate upon standing. Both of these components may be present in considerable concentrations, and both must be removed. Properly designed, conventional grease traps, such as those used for restaurant wastes, will remove floatable grease, but not emulsified grease. Emulsified grease may be removed in a practical manner, however, either (1) by passing the waste through a rock filter, or (2) by chemically flocculating the waste.

Where relatively low concentrations of emulsified grease are present, the rock-filter process may be successfully used. The rock filter serves to de-emulsify the grease, changing it to floatable grease so that it may be subsequently removed by simple trapping. Septic-tank units may be employed advantageously both for trapping the floatable grease and to serve as the container for the rock filter. The servicing required for this system includes removal of the accumulated floatable grease at regular intervals and occasional replacement of the filter rock. The sizes of the trap and rock-filter units will depend upon the quantity of the waste and its composition, as determined by laboratory analyses.

Where high concentrations of emulsified grease are present, a chemical flocculation process may be needed. For all of these processes (trapping, flocculation, and settling), septic tanks may be used as the most economical means of obtaining the necessary capacities. Also required, as accessories to the flocculation process, are a suitable electrically operated stirring device and a volumetric-type chemical feeder. Maintenance of the system includes keeping the chemical feeder stocked with chemicals and periodic pumping of accumulated sludge from the settling basin. In this process, the grease particles are agglomerated by the flocculating action into large particles which settle out in the settling basin. The sizes of the various tanks, the amounts of flocculating chemicals needed, and the frequency of pumping required will depend upon the quantity of the waste and its composition, as determined by laboratory analyses.

SLAUGHTERHOUSE, DAIRY, AND OTHER ORGANIC WASTES

These wastes are generally characterized by very high concentrations of organic materials, up to (and even exceeding) 100 times the strength of ordinary sanitary sewage. Part of the organic material is in true solution, and this may sometimes be disposed of by simple underground leaching, provided there is adequate area and provided a suitable schedule for resting the leaching areas is maintained. Much of the organic material, including the emulsified greases, is in colloidal suspension. Colloidal particles will clog underground leaching systems. They do not settle out on quiescence and, therefore, have to be removed by some means, such as by flocculation and sedimentation, or by application to trickling filters followed by settling. As in the preceding example, septic tanks may advantageously be used to provide the necessary tank capacities for the trapping, flocculating, and settling processes.

MINERAL OR INORGANIC WASTES

Mineral and similar wastes present special problems generally requiring chemical neutralization or other chemical treatment before the wastes may be filtered or leached into the ground. Important factors are the metallic and nonmetallic ions present, their concentrations, and, for underground leaching, the nature and importance of the water basin lying below the area intended for leaching. Septic tanks can sometimes be used advantageously in the solution of these problems, as chemical reaction chambers, settling tanks, etc.

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